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TECHNOLOGY
AND THE
AMERICAN ECONOMIC
TRANSITION

CHOICES FOR THE FUTURE

CONGRESS OF THE UNITED STATES OFFICE OF TECHNOLOGY ASSESSMENT

WASHINGTON, DC 20510-8025

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Foreword

In many studies during the past decade and a half, the Office of Technology Assessment has analyzed hundreds of changes in American life that have been brought about by new technologies. In this study, for the first time, OTA steps back from the detailed analyses of individual industries and sectors to take a broad look at the combined impact of new technologies on American society. From this perspective it is possible to describe the opportunities and risks for the nation as a whole that are not apparent in studies targeted on topics that are more narrowly defined. The report highlights strategic choices available to Americans as we negotiate a period of major transformation. The choices we make will have profound consequences for the quality of work and the amenities available to Americans and for America's role of leadership in the free world.

Eight committees of Congress asked the Office of Technology Assessment to assess the new environment in which America's economy now operates as a result of new technologies, a global market, and related changes in consumer attitudes and behavior. OTA was asked to identify areas where existing policy might block attractive avenues of growth and where new policies could facilitate growth. The requesting committees represent a wide spectrum of congressional interest. They include the Senate Committee on Commerce, Science and Transportation; the Committee on the Budget; the House Committee on Energy and Commerce; the Committee on Post Office and Civil Service; the Committee on the Judiciary; the Committee on Public Works and Transportation; the Committee on Education and Labor; and the Committee on Science Space and Technology.

The analysis begins and ends by focusing on people in their role as consumers and as employees. It uses conventional economic accounting procedures to document economic growth, but also employs more qualitative standards for measuring progress in eight basic categories of demand or amenity: food, housing, transportation, health, clothing & personal care, education, personal communication & business, and recreation & leisure. It also uses standard methods for measuring gains in compensation paid to workers, but introduces other ways of evaluating job quality such as opportunities for learning and career advancement, the extent to which work and family responsibilities can be combined, and whether a person can take pride in his or her work.

The first chapter serves as an introduction to the themes developed in the document and a summary and guide to the entire report. Readers will find this a useful way to identify sections on consumption, business structure, trade, employment, education, or other topics that may be of special interest to them. We feel that the major accomplishment of this document, however, lies in the way it helps develop a perspective on these issues—showing how the networks of production and consumption are interconnected, how international and domestic economies are connected, and how changes in one area spread through the nation's entire economic and social fabric.

The study was undertaken with the help of many individuals and institutions around the United States. We owe a particular debt to individuals in the U.S. Department of Commerce and the U.S. Bureau of Labor Statistics who not only provided data and reviewed OTA's work but gave us crucial insights and guidance about their complex resources. Responsibility for the contents of this document, of course, rests with OTA.

John H Gibbons

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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

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Chapter 1

Overview

INTRODUCTION

During the next two decades, new technologies, rapid increases in foreign trade, and the tastes and values of a new generation of Americans are likely to reshape virtually every product, every service, and every job in the United States. These forces will shake the foundations of the most secure American businesses. Few features of the change seem inevitable. The Nation's future has probably never been less constrained by the cost of natural resources or the limits of human strength, dexterity, or memory. Much less depends on physical limits to what *can* be done and much more on what Americans *choose* to do, acting privately as consumers, investors, and employees and publicly as voters.

The choices will affect the options available to consumers, the rate and nature of growth in different business sectors, the geography of growth, and the role played by large and small enterprises. They will affect America's position in the world economy and the number and quality of jobs the American economy produces.

This document is designed to describe the nature and consequences of some of these choices.

Given the importance of choice, it would be foolish to make confident predictions about the future of America's economy. It is possible, however, to outline a set of exciting possibilities. They include opportunities to: extend life and reduce sickness and disability; create more choices in recreation and entertainment; expand access to information about products and services; have products and services more precisely tailored to personal needs and tastes; and make learning more productive and accessible.

There are also opportunities for making work more rewarding—in all senses of that term. Technology can replace many of the most tedious, dangerous, and dehumanizing tasks while creating jobs that require more intellectual and social skills. Machines are likely to plant seeds, weave cloth, fabricate metal parts, handle routine paperwork, enter data, and perform a vast number of other repetitive tasks more efficiently and more productively than people. By default, the majority of jobs created in the economy could be those requiring human, and not machine-like skills: designing; tailoring products and services to unique customer needs; teaching; caring; entertaining; promoting; and persuading. Ironically, one result of sophisticated technology may be a work force whose primary task is dealing with people—as customers or as colleagues.

With each opportunity for progress, of course, there are opportunities for serious missteps. Even change that clearly leads to overall economic growth can have very uneven effects. Change can lead to wrenching dislocation and pain for workers with obsolete skills, for management unable to recognize opportunity, and for communities where traditional businesses have failed. Change can create an America in graceless decline—its living standards falling behind those of other world powers. This could mean an America less able to ensure the operation of free international markets and less able to ensure the security of the free world. Change can weaken the bargaining position of some groups while strengthening that of others. Change can result in a growing gap between those fortunate enough to have the talents, education, and connections needed to seize emerging opportunities and those forced into narrowly defined, heavily monitored, temporary positions. This latter group could be forced to bear most of the costs of uncertainty.

A central issue is at the core of the choices: will change increase or decrease the power of individuals? Specifically:

- Will it become easier to purchase products tailored to specific interests, or will choices be constrained as national production systems substitute standard products for specialized products reflecting individual interests or local tastes?
- Will businesses change and grow under the assumption that workers will be well educated and intellectually flexible, or will they plan with the assumption that workers will be ignorant, untrainable, and unreliable? Another way of asking this question is whether people will be able to find a variety of attractive opportunities for work, or whether only a credentialed elite will enjoy such opportunities.

From another perspective, the issue is whether the flexibility and dynamism essential to progress in the emerging economy will come at the expense of individuals, or whether individuals themselves will become more flexible because of continuous opportunity for learning and growth. In the past it seemed necessary to make a Faustian compact with technology: efficiency could be improved only by sacrificing individuality. Efficiency demanded mass production of uniform products, and a reasonable income often required acceptance of a constraining and narrowly defined occupation. It is at least possible that emerging technology will make it possible to avoid such a choice.

Can America operate a dynamic and growing economy and navigate a transition to a new, more flexible, economic structure without falling into any of many potential traps? Specifically, can the U.S. Government create a set of marketplace rules that bring private and public goals into greater harmony without stifling the innovation and entrepreneurship needed to reach these goals? Can both workers and investors have incentives to undertake major changes in production systems? Can a major transformation be managed so that unavoidable trauma will not all be borne by a single group?

The following pages argue that the answer to all these questions is yes—but only given an unflinching reexamination of some of the most cherished notions about the way businesses are managed internally, and about the way networks of enterprises work together. In the end, the choices governing the direction taken by the economy will be made by individual Americans acting as consumers with diverse interests, employees interested in rewarding work, and investors in search of profits. The rules under which these choices will be made are the issue. The collection of rules, regulations, and incentives adopted over the past several decades for perfectly good reasons may send misleading signals today.

Programs designed to create growth in new directions require an ability to think in clear, practical ways about the way skills and investment are connected to the provision of good health, recreation, and other amenities measured in human terms. The baffling complexity makes it easy to be misled about where real opportunities for progress lie. Indeed, it can make it difficult to believe in the possibility of system-wide progress.

The analysis that follows provides a practical set of tools for evaluating the performance of an economy that operates increasingly as a set of complex networks, which add value in many different ways and in many different locations before a product or service finds its way to a household. It also develops a set of concrete hypotheses about the way economic networks *could* operate in the future. The document does not attempt to forecast the future. Forecasting implies that choice plays a minor role. Instead, the analysis attempts to provide the clearest possible description of the available choices and their implications.

The changes discussed in this volume appear to make prescriptive government planning less desirable. This does not necessarily mean that the responsibilities of government are reduced. Government maintains a central role because it creates many of the rules under which private choices are made. It may also have a growing responsibility for ensuring that Americans have adequate access to education throughout their lives, for ensuring a continuous flow of invention and innovation, and for protecting individuals from the dangers and risks of rapid economic change.

Eight congressional committees asked the Office of Technology Assessment to take a broad look at the opportunities and risks created by the new environment in which America's economy now operates, in order to identify areas where existing policy might block attractive avenues of growth and where new policy could improve incentives.

Real economic growth requires both a belief that progress is possible and a vision of progress that is broadly shared. Government cannot create such vision, but it can provide a place where such visions emerge. The genius that has driven U.S. prosperity throughout its history has been an ability to combine collective vision with diversity and individualism—to unite grand ideals with hard pragmatism. As the United States enters the 21st century, this genius will be put to its severest test.

GUIDE TO THE ANALYSIS

Analysis by Networks

Given the broad goals of this analysis, it is necessary to take a very basic look at the way the economy operates as a whole. The vocabulary and the accounting techniques used to describe the economy, however, can limit our ability to imagine fundamental change. They embody many implicit assumptions about values and the way an economy operates. There is no obvious way, for example, to know whether a shift to an economy heavily based on "services" is either a fate to be embraced or avoided. In many manufacturing industries most employees never touch production equipment; more than half the cost of producing a computer, for example, typically results from software development. Should computer manufacturing now be considered a service? Many "service" workers are now involved in facilitating the design and delivery of manufactured products tailored to specific needs, or in facilitating the formation of production networks needed for timely delivery of new products. Should growth in these enterprises be read as the decline of manufacturing?

In an effort to avoid the traps of these and other abstractions, this analysis concentrates on some basic concepts:

- However sophisticated the economy may become in the future, its final products must always be the production of what will be called "amenity" throughout this volume. Amenity is intended to mean anything that contributes to the comfort, convenience, or happiness of an individual or household. While amenity is measured differently by every person, the "amenity categories" remain essentially unchanged in basic areas like health, food, housing, entertainment, and security. Progress in the economy must ultimately be measured by the extent to which the quality of these amenities has been improved, and by the extent to which these improvements are shared by the least fortunate groups in America.

  There are no easy ways to monitor gains in amenity. Growth in average income per person provides only a limited view of changes taking place. Averages, for example, can mask increasing differences between wealthy and poor households. Growth in spending on burglar alarms is obviously not a good measure of security. Increased medical spending is not a good measure of national health.

- However sophisticated the economy becomes, the networks providing amenity directly or indirectly generate all the employment created by the economy. Barring the development of a pill that increases native intelligence or removes the need for sleep, the basic resources of time, talent, and enthusiasm available in the work force will not be altered by any economic transformation.

  Change can, however, affect the mix of skills demanded throughout the economy, and the links connecting income to skill. It can alter the quality of education offered by the work force, and the capacity of workers to learn and adapt to shifting circumstances. It can alter the quality of jobs, the texture of a working day, and the extent to which a person can take pride and pleasure in the work. The quality of working life is itself an important amenity.

Most of the following analysis is devoted to an examination of the way amenity and jobs are connected in today's economy and the way these connections may change during the next two decades. Understanding these connections, of course, requires a clear understanding of the way a modern economy operates. The goal is to enter these intricacies without losing track of the fact that the analysis must begin and end with people.

Paradoxically, even in an economy increasingly based on information flows the simplest questions seem more difficult to address. The information available can be overwhelming rather than helpful. The analytical strategy proposed here attempts to close the gap between speculation based on anecdotes and quantitative analysis based on national economic statistics. It uses statistical analysis wherever possible, but combines these results with the insights of experts in areas where statistics are not available or are difficult to interpret. Above all, the method is designed to be flexible enough to describe opportunities for basic structural change.

A Parable

Before describing the methods of this study in more detail, it is useful to look at an example of a contemporary production network. What could be more basic than a frozen pizza? A man cooking a frozen pizza in a microwave oven cares about what the pizza costs, how it tastes, how its preparation fits into his increasingly harried lifestyle, and maybe a bit about whether it is good for his diet or health. In effect, he cares about the net productivity of the network of activities (including the time he invested in cooking and learning about health) that brought the pizza to his palate. He probably couldn't care less whether it was the product of a manufacturing economy, a service economy, an information economy, or an international economy. But consider a likely chain of events that culminated in the pizza. Knowledge about health effects of food came from a TV talk show and information about a sale on pizza from a newspaper ad. Wheat for the pizza crust was grown in Kansas using sophisticated seeds and pesticides. The pizza was assembled automatically and wrapped in materials that are themselves the product of considerable research. The pizza was probably purchased at a grocery store where a clerk passed it over a laser scanner, which entered data into a computer and communication system designed to adjust inventories, restock shelves, and reorder products. This system in turn made it possible to operate an efficiently dispatched transportation system, placing a premium on timely and safe delivery rather than on low bulk hauling charges. The checkout data were probably also used to analyze consumer response to the previous day's advertisement and to ensure that the store was closely following trends in neighborhood tastes.

This pizza parable is important because food remains a major part of the U.S. economy. The parable is even more important, however, because it contains many of the themes now reshaping the American economy.

It is difficult to argue that the United States has moved beyond an agricultural economy when one person in seven still works directly or indirectly to bring food to American tables. Demand for food continues, but the jobs involved in supplying it are very different from those of our grandparents. In 1984, only 4 of every 100 jobs in food production were on farms. The number of lawyers, bankers, scientists, and accountants needed to supply food in 1984 was about equal to the number of farmers. More than half the jobs supplied by the food network were for sales workers (20 percent), precision craftsmen (12 percent), managers (11 percent), and data entry clerks (10 percent).

Technology plays a crucial role at each step of the network of business activity just described. Foreign products enter at many points: the pizza may contain tomatoes from Mexico, may be prepared by food handling equipment from West Germany, and may be sold using checkout equipment from Japan. While the rules governing the network are primarily those of private markets, the role of government is pervasive. Government regulations control the safety and labeling of products. Public funds supply the highways crucial to food delivery. Many farmers spend hours finding ways to benefit from government farm programs.

Basic Tools for Representing Networks

The analysis presented in this study begins by dividing the entire output of the U.S. economy into 10 components, identified by the amenity they provide:

- Food,
- Housing,
- Health,
- Transportation,
- Clothing and Personal Care,
- Education,
- Personal Business and Communication,
- Recreation and Leisure,
- Defense, and
- government activities not elsewhere classified.

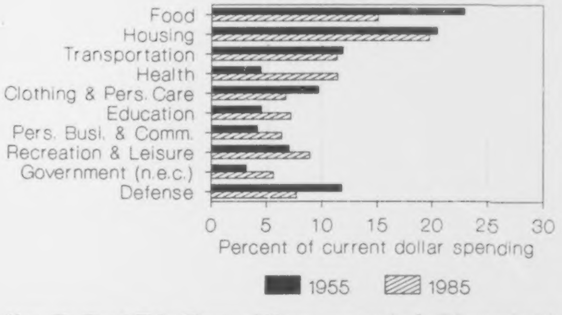
Only the first eight amenity groups are analyzed in detail in the material that follows. Changes in demand and in production efficiencies, have reduced the fraction of America's income spent on each amenity. During the past three decades, the fraction of spending used to purchase Food has declined while the fraction spent on Health, Education, Personal Business and Communication, and Recreation and Leisure has increased (see figure 1-1).

The amenity ultimately enjoyed by each individual or household is achieved through a complex series of steps, each of which adds value of some kind. The value may be contributed by investments of household time, or may be added by a business that contributes to a purchased product or service. The final value of a purchased frozen pizza, for example, includes value contributed by farmers, packers, truckers, wholesalers, grocery stores, and the collection of legal, financial, insurance, and other firms that facilitate transactions needed by the complex network of activities.

The methods this analysis uses to keep track of the flow of value in economy are summarized in figure 1-2, which illustrates four basic steps in the network connecting people as consumers to people as employees and investors:

1. *Consumption Recipes*. These "recipes" describe the way households achieve each amenity by combining time invested by household members, purchased goods, purchased services, and goods and services purchased by the government. (The mix of private and public spending in 1985 is summarized in figure 1-3.) A recipe for the amenity called "Health" includes personal time and money spent promoting good health (e.g., through diet and exercise), preventing disease and accidents (e.g., vaccinations, wearing seat belts, or taking drugs to control high blood pressure), and public investments in environmental quality, as well as clinical care purchased from doctors, hospitals, and a variety of other institutions. The formal and informal regulations guiding these decisions can be extremely complex. This document analyzes consumption recipes in each of eight sectors in two ways: first, by examining trends (based on

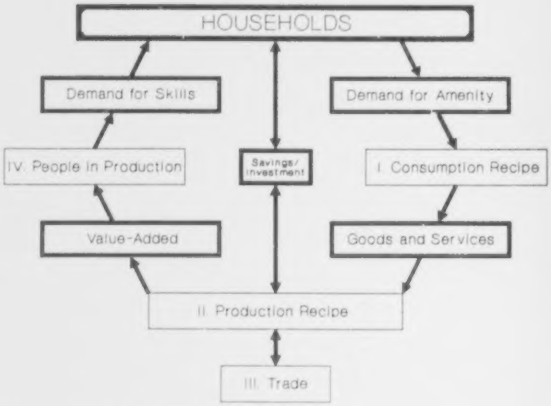
Figure 1-1.-How America Spent Its Money (percent of all personal and government spending in current dollars)



How To Read This Figure: Fifteen percent of all household and government spending in 1985 went to purchase food, down from 23 percent in 1955. The spending totals shown do not include the purchase of new housing since this is considered to be a form of savings.

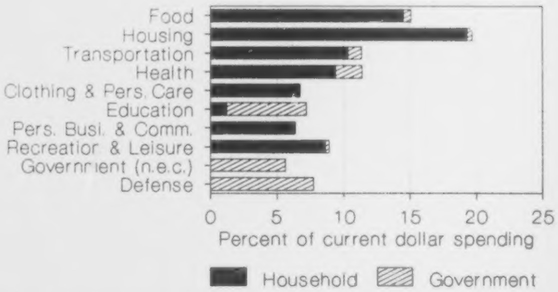
SOURCE: Based on U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 2.4, 3.15, 3.16 (see figures 2-1a to 2-1c of ch. 2 for detail).

Figure 1-2.-Structure of the Analysis



SOURCE: Office of Technology Assessment.

Figure 1-3.-Private and Public Spending on Amenities in 1985



How To Read This Figure: Of all household and government spending in 1985, 14.5 percent was spent by households to purchase food and 0.5 percent by government to purchase food or support food production.

SOURCE: Office of Technology Assessment (see table 2-2 of ch. 2).

a mathematical analysis of the way spending correlates with price, income, household structure, and other factors); and second, by examining the possibility that entirely new directions may be taken because of unexpected new products, changes in consumer education, changes in tastes, or changes in formal regulations.

2. *Production Recipes.* These "recipes" represent the mix of ingredients needed by producers to supply household and government buyers with products and services. Each business produces output by combining material and services purchased from other businesses with value that is added by the business itself. This value takes the form of labor performed by the business' employees and the returns paid to investors for use of capital. Tracing the value that ultimately appears in the price of a consumer product requires an understanding of the way value is added by a complicated network of businesses that supply each other. If the purchasing "recipe" of each business is known, it is possible to estimate the wages and profits generated in each sector in the process of satisfying the eight major classes of consumption. The result of such an analysis for 1984 is shown in figure 1-4.[1]

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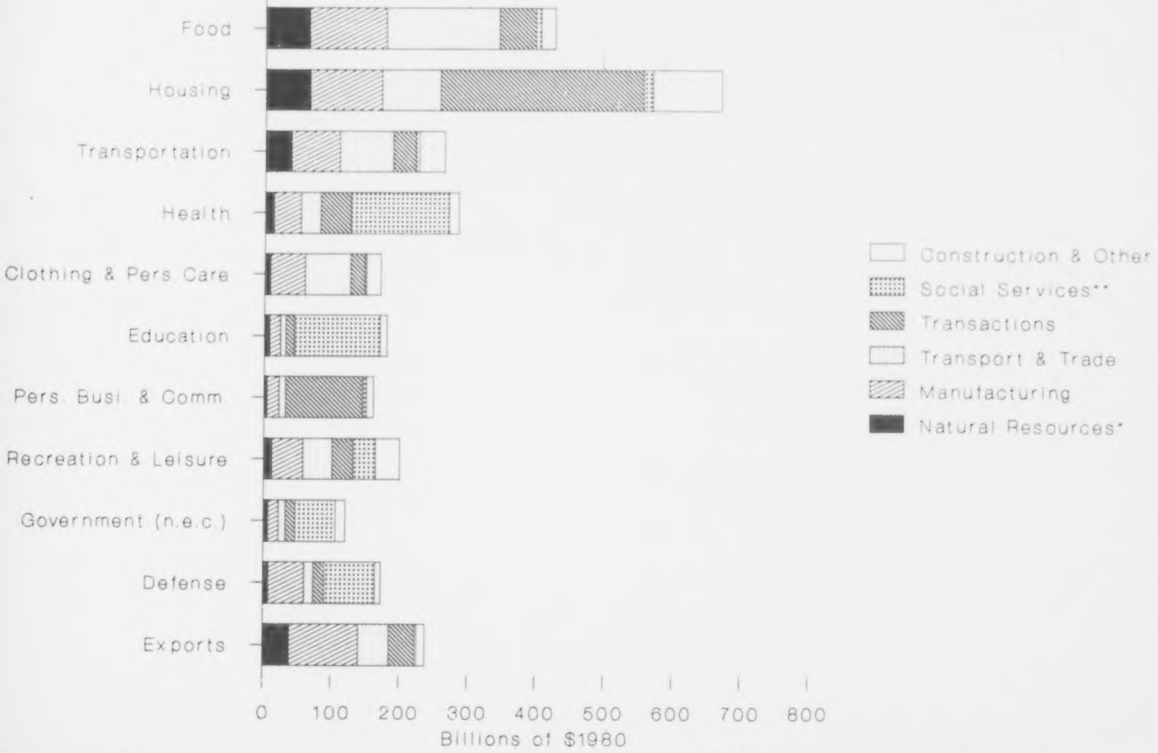
[1] Information in this and other tables displayed in this chapter must be treated with some caution. They are based on a large number of assumptions discussed in greater detail in later chapters.

Figure 1-4.-Where Is Value Added? (value-added by production sector in 1984)



How To Read This Figure: In 1984, the U.S. gross national product (GNP) was $2,890 billion (1980 dollars). Of this total, approximately $430 billion went to produce food for U.S. household and government purchasers. Of this $430 billion, $64 billion ended up as value-added (primarily employee compensation and profits) earned in Natural Resource businesses (a category that includes farming, fisheries, energy, and mining businesses). If the bars for each amenity group were placed end to end, the sum would equal the total U.S. GNP.

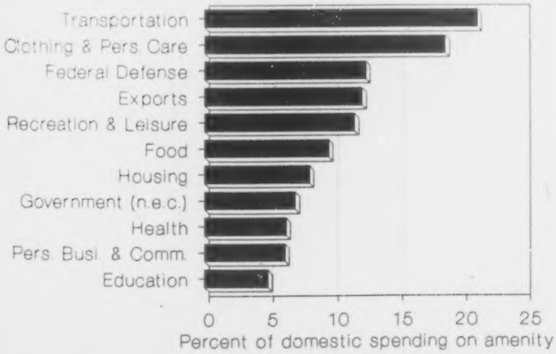
*Farming, Mining, and Energy.
**Education, Health, and other Government.

SOURCE: Office of Technology Assessment (see table 4-6a of ch. 4).

3. *International Connections.* Imported products have insinuated themselves into the domestic production recipes in complex ways (see figure 1-5), while nearly 10 percent of the U.S. gross national product (GNP) is sold abroad as exports. Trade of this magnitude obviously changes some of the basic rules under which domestic production networks operate. Different parts of the economy vary greatly in the way they are affected by trade. One dollar in five spent for Transportation ends up abroad, either directly (as in purchases of foreign cars or fuel) or indirectly (as in expenditures for steel used to produce automobile parts). About 12 percent of the price of products exported by U.S. firms results from imported products. Patterns of involvement can change rapidly. Housing, for example, was comparatively isolated from world trade in 1984 but there may soon be rapid growth in imported housing components.

Figure 1-6 provides a rough estimate of the way trade affects domestic employment. Estimates of the displacement effects of imports are highly artificial, since they depend on assumptions about how U.S. firms would produce substitutes for imports. Gains and losses exceed 25 percent in some sectors.

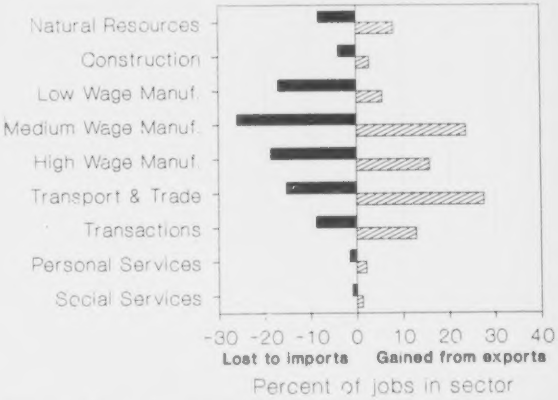
Figure 1-5.-Imports Used Directly or Indirectly To Produce Amenity in 1984



How To Read This Figure: 21.2 percent of the money spent by U.S. households and government for transportation in 1984 was spent abroad to purchase petroleum, automobiles, automobile components, and other products and services.

SOURCE: Office of Technology Assessment (see table 7-11 of ch. 7).

Figure 1-6.-Employment and Trade in 1984 (jobs gained and lost from trade)



How To Read This Figure: If there had been no exports of any kind in 1984, there would have been approximately 8% fewer jobs in Natural Resource businesses in 1984. If there had been no imports, there would have been approximately 8% more jobs.

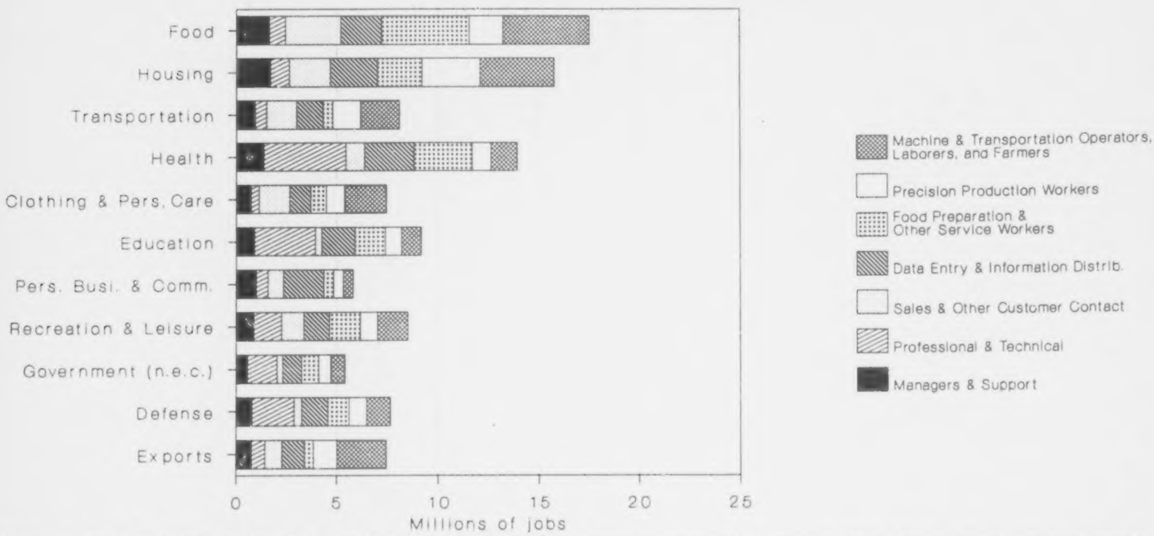
SOURCE: Office of Technology Assessment (see table 7-5 of ch. 7).

4. *People in Production Recipes.* The value that is added by each U.S. business depends on the contributions of employees with different kinds of skills. Figure 1-7 completes the network described at the beginning of this discussion by showing how effort by people with different occupations translates into amenity. Occupation is used as a proxy for skill since no other good substitute exists.

The American economy in 1900 allocated occupations to amenity very differently than the economy described by figure 1-7. A much larger fraction of all jobs would have been devoted to the production of Food and Clothing, for example, and a larger share of these jobs would have been directly involved with farming or other natural resources.

What might happen to such structures in the future? The method of analysis just described provides a systematic framework for examining hypotheses about changes in consumption recipes, production recipes, trade, and the use of skills in production. Public policy sets the rules under which choices are made in each of these four areas. These policies are discussed in greater detail in chapter 14.

Figure 1-7.-Jobs Required To Provide Amenity in 1984



How To Read This Figure: In 1984, the U.S. economy produced approximately 107 million jobs. Of this total, approximately 17.5 million jobs resulted from the production of food for U.S. households and government. Of these, approximately 1.6 million jobs were created for managers and management support occupations. All reported jobs in the U.S. economy are recorded somewhere in this figure.

SOURCE: Office of Technology Assessment (see table 10-6 of ch. 10).

Chapter 13 of this volume traces plausible hypotheses about changing choices in consumption recipes, production recipes, trade, and staffing by occupation. Figure 1-8 shows one of the many different scenarios examined. It represents an extreme case in that it shows what *could* happen if a major transformation occurred in each of the four analytical areas: consumption recipes that might improve amenity (for example, it assumes that investments in health promotion and disease prevention succeed); production recipes built around new paradigms (for example, it assumes a shift to a tightly integrated network connecting fiber production to retail apparel outlets); reduced reliance on trade; and a work force built around comparatively well-educated workers. It reflects comparatively rapid productivity growth with the real U.S. GNP rising at 3 percent per year.

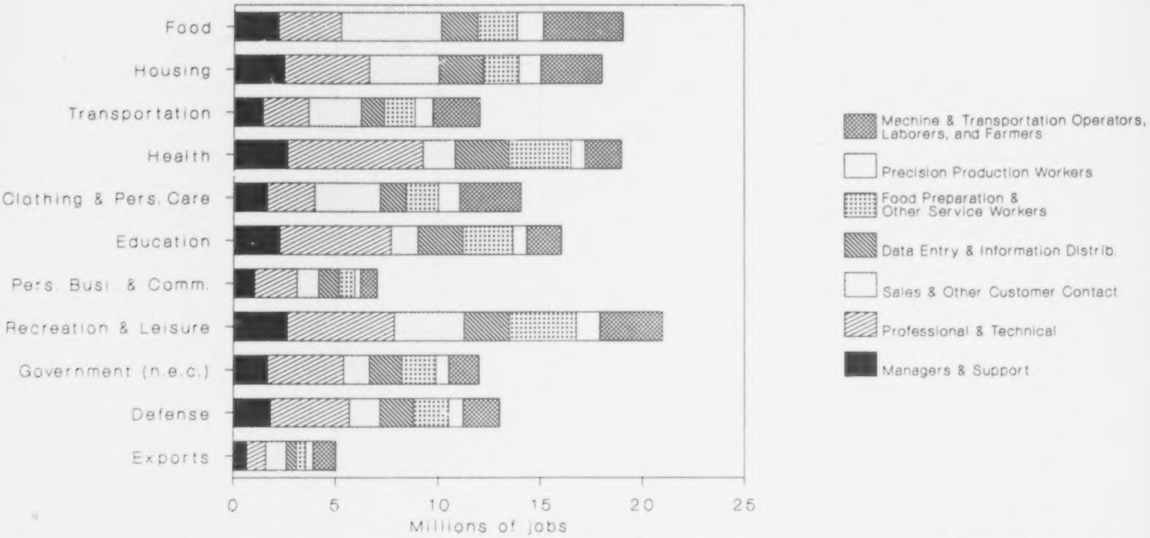
Under the hypotheses leading to the economy described in figure 1-8, productivity would greatly reduce employment in most mechanical jobs while employment in managerial, technical, and sophisticated clerical tasks would increase. Fewer people would be needed to provide basic materials or material processing. Many more would be needed to manage complex transactions and tailor products to individual needs. Since it is difficult to alter the productivity of tasks where direct human contact is essential, the share of all jobs required to provide education, entertainment, and basic government services (like fire, police, and other services) would increase in proportion to the rest of the economy.

Chapter 13 describes a variety of other scenarios. It may be possible, for example, to achieve high levels of amenity and a decline in the number of hours worked even though the dollar value of GNP grows comparatively slowly. There is no absolute way to measure the desirability of any of these scenarios.

Basic Characteristics of the Networks

Economic networks have been growing in size and complexity for some time. Each generation of new technology appears to increase the interdependence of businesses and individuals as well as the *number* of people and businesses tied together. Specifically:

Figure 1-8.-A Scenario of Jobs Required To Produce Amenity in 2005 (one of several considered)



How To Read This Figure: Several scenarios for the future structure of the U.S. economy are considered throughout this document. Under the assumption that significant, but plausible, changes occur in consumption recipes, production recipes, trade, and staffing patterns, this figure shows where jobs would be created in the U.S. economy in the year 2005. The format is identical to figure 1-7.

SOURCE: Office of Technology Assessment (see table 13-12 of ch. 13).

- Virtually no part of the economy now operates without heavy reliance on elaborate production networks. Production, marketing, sales, and transactional activities combine to deliver everything from frozen pizza to health care.
- Technology can increase the efficiency of a network acting as a whole as well as the performance of each enterprise in the network. Data provided by laser readers in grocery checkouts and improved communication systems permit efficient operation of tightly integrated networks of wholesalers, truckers, food processing firms, advertisers, and other businesses. This can be more important than efficiency improvements of any single business in the network.
- Taken together, new technologies can greatly increase the efficiency with which energy and materials are used. The efficiency gains, however, can typically only be achieved with increased spending for design and management.
- Intricate interconnections mean that problems and prosperity propagate quickly and affect many parts of the economy indirectly. Imports that affect a manufacturing firm also affect its web of suppliers. Exports create an elaborate trail of wealth.
- The new networks can have a surprising capacity for regeneration. New connections grow quickly when others are cut. Network components can shift rapidly to produce new products and services or to adopt new production strategies.
- Many of the networks have become international. Products, money, and ideas move about the world with new ease and speed. When production networks consist of many independent components, it is easier for both foreign and domestic businesses to enter.
- The complex networks have greatly expanded the role of transactional businesses—banks, lawyers, accountants, and communication specialists. Transactional costs can be measured by the increase in purchases of legal or financial services needed to make and enforce contracts, or

in purchases of other specialized business services. They can also be measured by the growth of management occupations and other transactional overhead costs in corporate bureaucracies.

- While disaggregated production networks could in principle spread economic activity widely in the United States, in fact they appear to have resulted in the concentration of economic activity in coastal cities. Businesses are choosing locations where they can find workers with adequate skills, and where extensive networks of personal contacts can be maintained. In the past much of American business needed easy access to natural resources.
- New networks are not only changing the relations between businesses, they are also changing the relationship between the market economy and the unpaid work done by family members. Capital investment in things like microwave ovens and video tape recorders ties households to food and entertainment networks in new ways. Child care, care for the elderly, and other "household" tasks are entering the market economy.
- People most likely to prosper in these networks are protean—able to change, adapt to unfamiliar work, and learn new trades as a continuous part of working experience. The talents needed are not clever hands or a strong back but rather the ability to understand instructions and poorly written manuals, ask questions, assimilate unfamiliar information, and work with unfamiliar teams. In short, the new networks require the skills provided by a solid basic education.

There is a paradox in all of this. Countries, establishments, communities, and individuals are finding themselves ever more tightly connected, and yet the networks allow more independence and choice. In particular, technology may tie production systems in different countries more closely together while nations may become less and not more dependent on imported supplies of energy, food, and manufactured products. The "green revolution" used technology to make many nations that were formerly food importers self-sufficient in food production. Material substitution and efficiency can reduce needs to import energy and minerals. In such situations the movement of materials may have decreased while the strength of linkages moving information, technology, ideas, and capital equipment has increased.

The shift to any new economic structure leads to effects resulting from the transition itself. These can often be difficult to distinguish from more lasting patterns of change. In a period of transformation one can expect rapid abandonment of older equipment (depreciation has grown steadily as a percentage of GNP), changes in business structure (rates of mergers, acquisitions, divestitures, and other transactions are extraordinarily high), and changes in demand for labor (there are large differences between the *average* job in the work force and the new jobs added during the past few years).

Policy Consequences

The depth of the changes underway in business networks, and the speed of change, requires a fresh look at policies designed to stimulate growth and mitigate the pain of adjustment. It is useful to divide options into two basic classes:

1. policies that affect the performance of the economy as a whole, changing rules in ways likely to facilitate choices made by consumers and producers; and
2. policies that facilitate the performance of specific networks like Education, Housing, or Health.

It is essential that the two policy strategies be coordinated. Policies designed to improve the performance of specific networks affect and are affected by programs designed to improve business performance through basic fiscal policy.

Analysis presented later suggests that production networks in diverse areas are becoming much more similar in the way they are managed, in the way they are linked to the rest of the economy, in the range of skills expected of employees, in the way they depend on the products of research and development, in the way they are regulated, and in the way they react to signals from the financial markets. Each network, however, retains unique features that must receive separate attention.

Programs designed to facilitate economic growth and expand the range of choices available to individuals can be built around the major elements of the network structure described in figure 1-2:

- The performance of *consumption networks* can be improved by providing individuals with more information, by ensuring that their education

is adequate to make informed choices in an increasingly complex society, by reviewing the incentives created by tax and regulatory policy, and by improving the way the government itself behaves as a consumer.
- *Production recipes* can be improved by changing the financial rules that may reward short-term profit taking over long-term investment, and by reshaping regulations that may place unnecessary constraints on the emergence of new production networks.
- The growth of *international production networks* makes it increasingly difficult to manage the economy in the absence of international coordination and cooperation. Regulation in areas as diverse as banking, communications, and antitrust needs to be undertaken with even greater attention to the way domestic networks are tied to international ones.
- Policy can influence the way employers use *people in production recipes* in a variety of ways. Policy can encourage employers to achieve flexibility through teams of skilled employees rather than by relying on "disposable" workers. A variety of incentives can be used to encourage compensation schemes that reward investment in training and that allow firms to adjust to hard times by reducing bonuses instead of laying off the most vulnerable employees. Policy can also encourage workers to be more flexible by reducing the pain of adjustment. Public investment and incentives can ensure employees access to training needed throughout a career. Retirement and health benefits can be made more transportable.

While the strategies are diverse, a number of themes emerge. Complex networks make centralized management of economic activity less feasible and less desirable. Networks in which productivity demands freedom to adapt and change may be impeded by regulation. This does not mean that planning is unwise, but rather that a new kind of planning is required. A firm confident in future demand for a specific product can plan to reduce costs through mass production. A firm certain that it cannot predict future demand must plan to have the flexibility needed to accommodate change.

The changing networks make it important to understand how the effects of public policy ripple through the economy. The flexibility of the emerging networks, for example, makes it comparatively easy for firms to evade conventional regulation. It can only become harder, and not easier, to define and regulate "banks," "emergency care facilities," "communication common carriers," or even "electric utilities." Restrictions applied to groups of products seem increasingly easy to subvert.

The problems associated with many kinds of traditional business regulation have led to an increased emphasis on programs designed to protect individuals rather than to regulate institutions. It is likely that this trend will continue. Steps can be taken to improve the information available to consumers as they make complicated decisions in areas ranging from health care to home purchasing. New rights to education, insurance, and pensions can be given to individual employees. New steps can be taken to ensure that markets take adequate account of safety, environmental, and other costs. These are difficult enough to regulate when production systems remain comparatively static. They are more so when systems are in flux.

Earlier economic transformations were associated with a major public investment in infrastructure: canals, railroads, electric lines, and highways. The transformation taking place today seems to require an entirely different kind of public involvement. An educated population is the most critical infrastructure of the emerging economy. It is critical for both the economic growth of the Nation as a whole, and the success of individuals acting as either consumers or employees.

Education has, of course, always been a central interest of American policy. Two things are new. First, the emerging economy places an unprecedented demand on the intellectual skills and knowledge of American workers. Old standards of competence are no longer adequate. Second, technology is making it possible to look for significant changes in the productivity and quality of teaching and learning for the first time. A system allowing any person, anywhere, with any background, and any assortment of gaps in education, access to training on any subject is within the state of the art of existing technology.

The Structure of the Report

It is obviously difficult to take a many-dimensional network and describe it in a linear prose essay. Figure 1-9 illustrates how the remainder of this document is organized. Each of the four major parts covers a different element of the American economic system. Each introduces a set of analytical tools for using national statistical series to look at economy-wide patterns of change. Each of the four parts, however, also contains a discussion of issues unique to each amenity network. These analyses are based on an enormous variety of sources ranging from national statistical accounts to specialized journals. The analysis of specific networks includes an effort to define progress in areas like Health and Education, a description of the peculiar features of each network, an analysis of trends in the way the network operates, and speculation about how it could operate in the future. These examinations include a review of changes in patterns of consumer and government purchases, changes in the way producers combine to deliver products and services (and the net productivity of these combinations), and changes in the way people with different skills are linked together directly and indirectly in these networks.

The final two chapters pull the pieces together. Chapter 13 develops a set of hypotheses about the future structure of the economy built from a series of specific hypotheses concerning consumption, production, trade, and labor. Chapter 14 reviews options for revising the regulations and incentives that shape the direction of U.S. economic growth.

Figure 1-9.-Organization of the Volume

Chapter 1: Introduction and Summary

	Consumption Networks	Production Networks	Trade Networks	Labor in Production Networks
Setting Up the Analysis	Chapter 2	Chapter 4	Chapter 7	Chapter 10
National Trends	Chapter 2	Chapter 5	Chapter 8	Chapter 11
Analysis of Specific Amenities	Chapter 3	Chapter 6	Chapter 9	Chapter 12

Chapter 13: Defining Alternatives

Chapter 14: Defining Choices

SOURCE: Office of Technology Assessment.

SUMMARY

The following section provides a brief summary of the topics covered throughout the remainder of this volume. The reader is due two warnings before proceeding:

1. No attempt is made in this summary to provide references for facts or detailed arguments in support of conclusions. For this, the reader is referred to the sections of the report cited.
2. The discussions result in an assessment of strategic choices and provide a list of specific policies that could be used to implement these choices. The discussions of choice are divided into two parts. The first part outlines a set of public policy goals and objectives that grow directly from the analysis of this report. The second part, which suggests options for achieving these objectives, enjoys no such connection and has not been analyzed in any detail. *The options are offered to demonstrate that public choice can have a significant effect in moving the economy toward a desired objective. They are not intended to form a comprehensive list. Neither the costs nor the benefits of specific options are estimated in detail.*

THE NEW RULES

The rules under which the economy operates are being reshaped by four major forces:

- new technologies—primarily those built around microelectronics;
- the loss of U.S. preeminence in international markets;
- the possibility that the price of energy and other resources may increase sharply by the turn of the century; and
- changes in consumer and labor markets and a new attitude toward public regulation of economic activity, resulting—at least in part—from new values and tastes.

Taken together, these forces appear to open more opportunities than they foreclose.

New Technology

Technology has forced the U.S. economy through profound changes in the past and shows every indication that it will do so again. The introduction of steam power, railroads, and mass production equipment at the beginning of the 19th century serves as one example; the development of electric power, inexpensive steel, automobiles and telephones at the beginning of the 20th century provides another. These inventions did much more than improve on the way things had been done in the past. They changed basic conceptions about the limits of human ingenuity, removing seemingly insurmountable barriers. Moreover, they had effects going far beyond the markets for which specific inventions were originally developed. Each cluster of technologies led to rapid growth in wealth, standards of living, and employment. The texture of everyday life was transformed.

Weaving machines, for example, took work that had been performed in most households for generations and moved it to towns and factories. Inexpensive cloth improved comfort and sanitation and revolutionized fashion. New techniques used in the production of textiles and apparel turned villages into cities, changed the terms of international trade, and helped make England a world power.

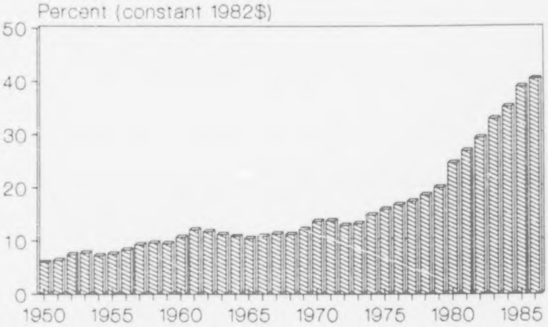
The automobile quickly became more than just an improved horse. Affordable cars reshaped everything from the design of cities and suburbs to styles of courtship. They generated noise, pollution, accidents, poetry, and an unimagined range of personal mobility. A curiosity at the beginning of the century, auto production dominated U.S. industry by the 1950s.

Do the technologies now entering the economy have the potential to so transform society that their impact can be considered revolutionary? Can any of them do something that could simply not be done before, or reduce costs to a point where they can change basic paradigms of production throughout the economy? These are not easy questions. An overwhelming body of evidence suggests, however, that new technologies for collecting, storing, manipulating, and communicating information do have the potential to revolutionize the structure and performance of the national economy. They would have this potential even if the technology were to freeze at present levels—which it plainly will not. This is not to say that other emerging technologies will not also have a significant effect on the economy. Bioengineering can reduce the incidence of disease, extend life expectancy, reduce the cost of producing food, and improve the quality of American life in a variety of other ways. New materials can improve the performance of machines ranging from automobile engines to space stations. But while surprises are to be expected, it is likely that most of these technologies will do something familiar in a better way—at least during the next two decades. Information technologies have the potential to change the performance of the economic system itself.

If a revolution of some sort is underway, measuring its impact with any precision has proven to be exasperating. As in the past, technologies with the power to reshape the basic structure of production have effects where they are least expected and where official government statistics are poorly designed to chronicle the change (statistical series are usually best suited to chronicle the previous technical revolution). Some evidence of the astonishing impact of the new technology, however, can be seen in the fact that over 40 percent of all new investments in plant and equipment are now in a category called "information technology"—computers, copying machines, and the like. This is double its share in 1978 (see figure 1-10).

Much of this equipment is purchased by businesses specializing in transactions (law, banking, insurance, etc.), education, retail and wholesale trade, and in parts of manufacturing, health, and transportation traditionally associated with "overhead" or "margins." These are businesses where output cannot be measured in concrete terms. Convincing evidence of productivity growth has yet to be measured in many of these businesses. It is difficult to determine whether this is a transitional effect associated with learning during a period of massive change, a defect of measurement, or a real limitation of the technology.

Figure 1-10.-Investment in Information Equipment as a Percent of all Investment in Producer Durables



How To Read This Figure: Measured in constant 1982 dollars, 40.4 percent of all producer's durable equipment (PDE) was spent to purchase computers, communication equipment, or related information equipment in 1984. About half of all investment in the U.S. is spent for PDE, the rest is used to purchase houses, and other construction products.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 5.7 (see figure 4-1 of ch. 4).

The transitional problems associated with learning how best to use information technologies are large. As was the case with earlier innovations, however, the more sophisticated information technology becomes, the easier it is to operate and the more widespread is its adoption. It would have been difficult for James Watt to believe that heat engines (in automobiles) could be operated by people unable to distinguish a wrench from a peony. Information equipment has made an important transition during the past few years. Computing power once confined to specially equipped, air-conditioned rooms has already insinuated itself into everything from automobile carburetors to greeting cards and teddy bears. Like the carburetor, the computer has become invisible for most users.

One of the problems of measurement is that information technology affects the structure of the economy in unexpected ways. Three areas appear to be of particular importance:

1. *Information technologies can increase the productivity of operations where real productivity changes once seemed so remote that they may never have been considered seriously.* Paper shuffling occupations provide a prime example. Clerical or quasi-clerical data entry, processing, communication, or manipulation is the principal

occupation of at least 16 percent of the work force (27 percent if managers are included). The potential productivity gains in this area—the movement and organization of information—are at least as great as those produced when the first Industrial Revolution began to revolutionize productivity in moving and transforming material objects.

Education provides another unexpected example. At least 8 percent of the work force is engaged in teaching. The new information technologies have the potential to increase the quality and the quantity of learning that occurs per unit of a student's time and per unit of teaching time. Quality means learning in greater depth. It means an ability to tailor teaching techniques to individual abilities and more time for teachers to talk to students.

Making full use of information equipment, however, requires a willingness to undertake a basic reexamination of management strategies and job descriptions. This is always a painful and uncertain process. Successful use of new information equipment seldom involves the direct replacement of a task by automation. Instead, entire operations (like data entry, filing, and routine management tasks) may be replaced with a combination of information equipment and jobs with new responsibilities (typically "quasi-professional" jobs involving clerical, interpersonal, and analytical skills). The potential for using technology in education depends on a willingness to reshape what is taught, where it is taught, how it is taught, the point in a person's career when it is taught, and the range of talents needed by the teaching staff.

2. *Information technologies have the potential to link production systems together in ways that improve the performance of entire networks.* These technologies can make it easier to serve large numbers of highly specialized markets. They make it possible to tie together complex networks of producers around the Nation or around the world by forging tighter links between retail, wholesale, transportation, and manufacturing operations. They also make it possible to concentrate production in areas where labor skills, wages, business conditions or living conditions are judged to be favorable.

   Fundamental changes in management practices are needed throughout business networks if the full potential of the new technology is to be harnessed. Many such changes are already underway. Unprecedented scrutiny of management practices, inventory control, sales strategies, and other activities has already led to the growth of tightly integrated systems connecting manufacturers and business services. Tight networks now connect grocery stores to warehouses to food producers. Networks will shortly tie clothing retailers to apparel manufacturers to textile producers to the fiber industry. These changes impose a range of new demands on production technology and supporting services. For example, the new systems place a premium on rapid response and efficient batch production rather than on mass production. They place a premium on fast, reliable transportation of comparatively high-value products, rather than on low-cost transportation of bulk materials. As a result, they demand considerable support from service enterprises.

3. *Information systems can change the ways business performance and financial information are gauged, and can increase the rate at which markets respond to new business conditions.* Information technology that can make information both cheaper and easier to use can obviously have a deep, though subtle, effect on the efficiency of a free economy. It can affect both how producers organize their activities, and how consumers decide to spend their money.

   Time-sensitive prices of such things as electricity can be continuously communicated to individual residences, for example. Businesses can also be made much more sensitive to market trends, and can tailor production planning more closely to market demand.

   The international stock market crash of October 1987 provided a stunning reminder of the way that information processing equipment (facilitated by regulatory change) allows enormous amounts of money to shift hands quickly. The equations imbedded in the computer software conducting such trading do not just anticipate the performance of the national economic system but, to a major extent, have become part of the system. Regardless of whether this practice should be celebrated or condemned, there can be little doubt that information is influencing the way national capital resources are allocated.

New Challenges From Abroad

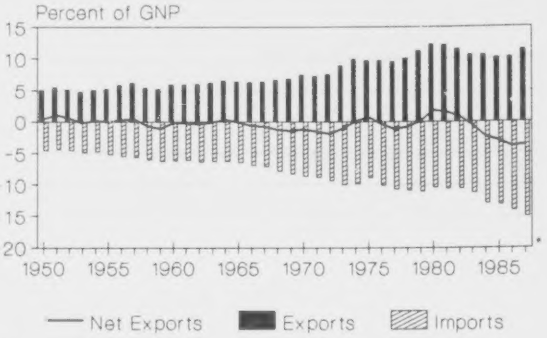
The networks that combine to deliver amenities to Americans have taken on an increasingly international dimension. Exports and imports nearly doubled their share of GNP during the 1970s (see figure 1-11).

The factors that make it possible for producers to divide production into separate steps in comparatively small establishments located across the country also make it possible to tie foreign producers into these networks. Once confidence is developed in foreign suppliers, it is easier for U.S. firms to expand operations abroad; once foreign producers establish a reputation for quality, they can build on this reputation. The process is cumulative and, barring catastrophic events, irreversible.

While the establishment of familiar links with foreign producers irreversibly opens the *potential* for foreign production, these links do not necessarily imply a continuing expansion of foreign production. Long transportation and communication lines add costs, both directly through increased shipping and inventory costs, and indirectly through inflexibility. Domestic ingenuity can be substituted for foreign supplies of energy and materials. It is entirely possible that the advantages of quick access to domestic markets and production links will offset any advantages of foreign production. This topic will appear repeatedly in this analysis.

The growth in trade over recent decades has resulted largely from the economic recovery of Japan and Western Europe following World War II. This recovery was, of course, a central goal of U.S. foreign policy for four decades—based on the sound belief that prosperity is a strong bulwark against Soviet destabilization. A second major factor has been the explosive growth of Korea, Taiwan, Hong Kong, Singapore, and other producers on the Pacific Rim who have developed rapidly, in large part because of their ability to offer competent workers with a sound basic education at low wages. In 1970, 40 percent of South Koreans of appropriate age were in the equivalent of high school. In 1982, 82 percent were enrolled. It also appears that the quality of the schooling received is high.

Figure 1-11.-Exports and Imports (percent of GNP in constant 1982$)



How To Read This Figure: In the third quarter of 1987, exports totaled about 11% of the U.S. GNP while imports totaled about 15%. The trade deficit was about 4% of the GNP.

*1987 third quarter.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 1.2 (see discussion in ch. 8).

The gap separating productivity levels in Japan, Australia, the United States, Canada, and major European economies has been cut in half during the past 100 years. This has meant a convergence in living standards, incomes, and labor costs.

There are some obvious reasons why followers gain on the leaders. Imitation is much easier once the basic paths have been revealed. Ideas flow rapidly—increasingly so, if some recent studies are to be believed—across international borders. Expanding economies are more likely to take risks with state-of-the-art production systems than established firms with large investments in existing equipment.

While loss of overwhelming U.S. dominance in world trade was expected, the rapid erosion of U.S. capabilities in advanced technologies was not. The theory of the "product cycle" seemed to explain U.S. leadership for many years. The theory was based on an assumption that U.S. producers operated in an economy with some of the world's most affluent consumers and best paid workers. Technologies developed for such an economy were unique, emphasizing high labor productivity and sophistication. As other nations approached U.S. living standards, and as the technologies involved became comparatively routine, they would naturally pass out of U.S. hands while U.S. producers moved to ever more sophisticated production.

This cycle has not only been slowed by the convergence of living standards, it may have been reversed. Foreign firms, recognizing that dynamic exploitation of technology is the key to international competitiveness, may have taken the lead. Having broken the product cycle, foreign producers are suddenly in a position to finance the next generation of technology with income earned from sales of the current generation. U.S. producers are left trying to leapfrog competitors without such a revenue source. In the case of consumer electronics, U.S. producers appear to have all but abandoned the effort. The rules of trade have changed in fundamental ways for U.S. producers. Increased linkages in the domestic economy also mean that trade problems in one area (e.g., manufacturing) quickly translate into problems in many parts of the economy (e.g., business service firms that owe a good portion of their livelihood to domestic manufacturing).

Loss of U.S. dominance does not mean that U.S. living standards will necessarily fall; indeed, living standards in the United Kingdom rose steadily for a century after it lost its dominant position in the world economy. It simply means that undisputed U.S. economic leadership may be lost. Certainly, it is now possible that the United States will find its living standards in decline with respect to its competitors, and discover its role as an economic and military leader of the free world called into question during the next two decades.

New Resource Constraints

The availability of natural resources once dictated the pattern of the U.S. economy. Today, as industries learn to make more with less and to substitute light, high-value products for heavy, cheap ones, far fewer firms are constrained by lack of resources. This is already altering the geography of U.S. industry in major ways.

But two natural resource issues will continue to demand attention: the availability of petroleum, and the limits of the environment's ability to absorb waste. Both can be surmounted given adequate planning. Without such planning, the comparatively heavy energy dependence of the United States could become a major liability. U.S. lifestyles would suffer if the price of petroleum increased suddenly (60 percent of U.S. petroleum consumption is for personal vehicles); furthermore, the comparative energy inefficiency of U.S. products (cars and appliances, for example) and production systems could make U.S. products less attractive in international markets and foreign products more attractive in U.S. markets. Resource policy leading to inefficient energy use can also lead to inefficient use of capital. Lack of attention to energy efficiency resulting from poor utility regulation, for example, can lead to massive diversion of capital to energy projects.

With current technologies, rising energy use translates into growth in solid waste and increases in air and water pollution. Fortunately, technology that improves the efficiency with which energy and materials are applied to products and services usually has the serendipitous effect of simultaneously reducing emissions. While energy use per dollar of GNP in the United States is still nearly twice that of Europe and Japan, it fell 25 percent during the 1973-86 period. U.S. consumption of steel, cement, paper, ammonia, chlorine, and even aluminum per dollar of GNP and per capita has either stopped growing or begun to decline. Electricity was the major exception to the trend, increasing nearly as fast as GNP since 1970.

New Values and Tastes

Another basic change in the rules involves changes in the tastes and values that motivate decisions in consumer markets, public spending, and labor markets. Changes in these areas have had dramatic and sometimes complex influences. Strenuous objections to nuclear power in the United States, the growth of the environmental protection industry, new interest in exercise and nutrition, and the growth of female participation in the work force have all resulted primarily from changes in values having little to do with economic forces.

Demographic and Social Factors

The size and structure of U.S. households and the role of women in the economy have both changed dramatically over the past decade. There has clearly been a change in the behavior that Americans find acceptable, and a consequent increase in the range of choices available for individuals. These changes come on top of an underlying pattern of demographic change of no small consequence. Taken together, they have been responsible for qualitative changes in patterns of consumer expenditure and in labor markets.

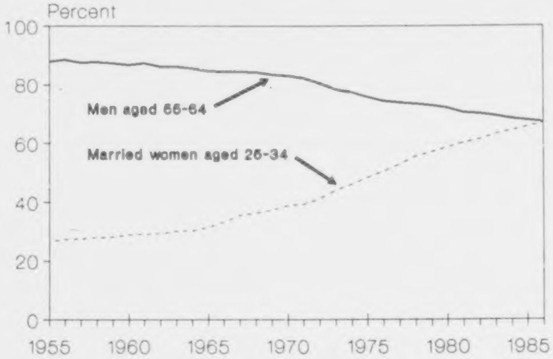
Those born during the baby boom recently left the Nation's educational system. They are now at an age to make major consumption decisions—decisions that often reflect changes in values from the generation they have replaced. This generation has created booms in a number of markets (such as increased spending on health, fitness, and travel), and in some areas this has led to congestion. Many young families are discovering, for example, that population pressures in areas where new jobs are being created have driven prices for housing to levels that are prohibitive for new home buyers.

This process is paralleled by a growing population of elderly people and a radical transformation in the size and structure of households. Divorces, late marriages, and growing acceptance of previously unacceptable living arrangements, such as single-parent households, have led to a rapid growth in comparatively small households. The average size of an American household fell from 3.3 people in 1960 to 2.7 in 1986.

Women are now much less likely to leave the work force even when they have young children. Many are forced to work since they are the sole source of support for their families. Moreover, the expansion of female employment opportunities has meant that women are much less willing to subsidize the economy with poorly paid work. Markets for nurses, teachers, and other traditionally female occupations have changed greatly as a result.

The increase in female participation has been offset by a sharp trend toward early retirement, resulting in part from more generous retirement programs and in part from a troubling trend toward the disposal of older workers for whom retraining is not judged to be profitable. Young married women are now as likely to be in the work force as older men (see figure 1-12). The number of hours worked in the economy by the average *adult* (age 16 to 65) seems to actually have declined during the past decade. Since the baby boom has recently increased the percentage of all Americans who are adult, however, the number of hours worked per member of the *total* U.S. population has increased.

Figure 1-12.-Work Force Participation for Older Men and Young Married Women



How To Read This Figure: In 1986, approximately 67 percent of married women aged 25 to 34 participated in the work force (e.g., were working for pay or actively looking for work). Approximately the same percentage of all men aged 55 to 64 participated in the work force.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Handbook of Labor Statistics*, Bulletin 2217 (Washington, DC: U.S. Government Printing Office, June 1985); data since 1983 provided by the Bureau of Labor Statistics (see discussion in ch. 11).

Changes in Public and Private Regulations and Incentives

The phrase "regulations and incentives" is used throughout this document to mean the answer to the question "What explains the behavior of the individuals involved in economic activity?" These rules fall into two basic types: the profit motive of free markets, as modified by formal incentives and regulations promulgated by the government; and informal patterns of management that have evolved historically, often without reference to economic logic.

For better or for worse, both the formal and informal regulations governing the U.S. economy are undergoing changes that increase the freedom of American businesses. This is not a return to a halcyon past that was free of regulation. Most business activity was much more heavily regulated in the past.

Regulatory reform has eliminated or greatly reduced controls that once tightly constrained competition in enterprises throughout the economy. Many emerging technologies have the effect of reducing the size of economically competitive facilities. In some circumstances, privately owned phone switches can compete with utility telephone switches, and cogeneration plants can compete with utility generation of electricity. Other technologies have introduced competition in areas once dominated by a single technology (such as alternatives to broadcast television and business communication systems). The result has been to undermine the logic of using principles of "natural monopoly" to regulate broad areas of the economy. Pressures of international competition are also destroying many traditional management mechanisms in businesses ranging from textiles to insurance.

While the logic of monopoly control may have been altered in many ways by the emergence of new technologies and demands for new network flexibility, the changes may increase the need for regulation to protect the health, safety, and privacy of *individuals.*

Perhaps the most critical question has to do with the motivation of individuals. Hard work, dedication, and inspiration cannot be entirely explained by looking at how a rational person would maximize income under prescribed rules. What keeps an inventor working through the weekend? The prospect of fortune plainly helps, but interviews with innovators continually suggest that much more is involved. A sense of pride, the admiration of colleagues and employers and, at least in traditional societies, a sense of contribution to a collective or national accomplishment all play a critical role. Interviews with entrepreneurs who left large firms to start their own repeatedly suggest that a desire for independence contributed as much as a desire to earn more money. Public or private rules that frustrate such intangible individual incentives are unlikely to promote real national growth.

CHOICES CREATED BY THE NEW RULES

The rules shaping opportunities for economic growth have changed in ways that undermine many basic paradigms for public and private management. Deep structural changes are underway in virtually every U.S. business sector. Some are painfully obvious: firms threatened by extinction in the face of foreign competition, or a health care industry revolutionized by new technology that has overwhelmed traditional means for managing health financing. In other parts of the economy, change is more subtle: an insurance industry in which products and production processes have been transformed by competition and new information technology, or a transportation system reshaped by new demands for speed, reliability, and quality in the delivery of comparatively small, lightweight products. Still other parts of the economy (education and home building, for example) remain comparatively stable, but there is potential for major change.

The choices created by the new rules are viewed from two perspectives: 1) structural change underway at the level of the entire economy and the policy choices presented by these changes, and 2) structural change underway in specific amenity networks and the choices presented by these changes.

Changes affecting the entire economy are measured by shifts in the relative role of different types of businesses (e.g., farming, manufacturing, and service enterprises), in the nature and volume of trade, and in the kinds of jobs created and lost. Choices exposed by an examination of economic performance at this level suggest a review of the incentives and disincentives created for businesses by laws affecting finance, trade, and labor policy. In many cases these signals seem incompatible with the course of action most likely to capture the opportunities of the new rules.

Changes in the performance of specific amenity networks can only be seen by examining the unique features of Health, Education, Transportation, and other sectors. Each require programs specialized to their unique problems and opportunities. Choices made about such programs work best when coordinated with programs designed to stimulate innovation and growth throughout the economy, and when made with a clear view of problems and opportunities shared by different sectors.

Economy-Wide Structural Change

The following discussion examines structural change in the U.S. economy by tracing changes at each of the four stages that connect people as consumers to people as employees and investors described in figure 1-2:

1. changes in consumer and government spending (consumption recipes),
2. changes in the way purchased goods and services are produced (production recipes),
3. changes in the way trade modifies these production recipes, and
4. changes in the use of people in production recipes.[2]

Each of these discussions lead to a distinct set of choices for public policy.

Consumption Recipes (Ch. 2)

The term "consumption recipe" is defined to mean the combination of private and public investment used to achieve an amenity like good health (see table 1-1). These recipes are based on a complex combination of logic and whimsy. They are shaped by changes in demographics, incomes, income distribution, prices, and by the emergence of new products and services. They can be strongly influenced by public regulation, tax policy, and information.

Describing Recent Trends.—American households are looking for—and finding—greater quality and diversity in products and services. This results in part from the fact that U.S. households are growing more diverse, and in part from the fact that technology and trade bring a greater variety of products to market at prices not significantly higher than those of "mass produced" goods. Technology also makes it possible to reach small markets efficiently.

While the rate of change in household types is likely to slow during the next two decades, the new diversity of American households will continue to shape demand for products and services tailored to a range of interests as the baby boom generation moves through middle age. Only one-fifth of households now have a working father, a housewife, and children, down from about one-third in 1972. Households headed by the elderly are increasing rapidly.

Changing incomes and income distribution also shape purchasing patterns. Higher income families, for example, tend to spend a higher fraction of their incomes on Recreation, Education, and Clothing and less on Food and Health. Demographic effects (particularly the increase in households headed by single women) and inequality in the distribution of property-type income has led to greater inequality in the distribution of after-tax income among families. While income distribution is obviously important for reasons of social policy, it has a surprisingly small effect on levels of relative spending in major consumption categories.

Direct consumer purchases of services are increasing. Much of the growth has been in the form of demand for financial services (including credit), hired substitutes for work formerly performed by unpaid household labor (like child care and care for the elderly), and increased expenditures on health care. A declining share of U.S. income has gone to purchases of Food, but the share spent on food-related services (primarily in restaurants) has increased over the past 30 years.

Purchases of energy and materials are declining as comparatively light, high-value products (such as personal computers) represent an increasing share of purchases. Purchases of heavy durables are leveling off. And people are buying more and more products tailored to their specific needs, from magazines to insurance policies. There has always been a demand for tailored services of this kind, and new technology is now making it possible to serve specialized markets by lowering the differences in cost that have traditionally made batch production more expensive than mass production.

Purchasing decisions also depend heavily on the availability of a person's time. Americans reported spending 108 minutes more per week in paid work, commuting, and household-related work in 1985 than in 1975; they therefore had less free time for eating, personal care, and other household activities (see figure 1-13). There was less time for housekeeping as well. Men did approximately 1 hour more housework per week in 1985 than in 1975, but women did about 5 hours less per week. Time avail-

Table 1-1.—Elements of the Consumption Recipe

Household purchases from labor and capital income
+Household purchases from transfer and other income
+Unpaid time of household members
+Government purchases of goods and services
=Total final demand

SOURCE: Office of Technology Assessment, 1988.

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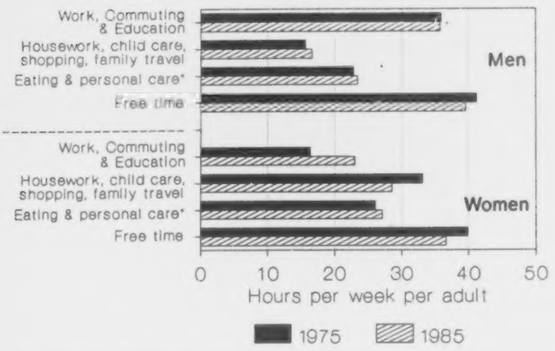
[2] The compensation and unearned income generated in step 4, of course, provide a basic constraint on purchasing patterns described in step 1. The analysis is designed to be internally consistent, but no attempt is made to produce a closed economic model.

Figure 1-13.-American Time Budgets



How To Read This Figure: In 1975, American women 18 years of age or older had 40 hours per week for "free time" activities (organizations, social life, recreation, television and other electronic media, leisure travel, etc.). By 1985, this had fallen to 36.6 hours.

*Not including 7.5 hours/night.

SOURCE: Office of Technology Assessment (see table 2-3 of ch. 2).

able for leisure also seems to have declined in the past decade, in part due to the 40 percent increase in work-related hours. Women were affected the most, losing an average of 3 hours free time per week. Both sexes spent much less time spent socializing and participating in social organizations. There was even a slight decline in time spent watching television.

The mix of private and public spending used to achieve amenity has remained remarkably stable at levels that were shown in figure 1-3. There are some exceptions. For example, two-thirds of medical spending came directly from patients in 1950. In 1983, 73 percent of all spending came from insurance companies or government programs.

Strategic Choices.—An economy that increasingly takes the form of complex and interlocked networks can have the effect of putting more power in the hands of consumers. While the complexity of choice increases, the time available for making informed decisions is declining for many households. The joy of frivolous and capricious purchases and the principle of "caveat emptor" are obviously important driving forces in a free economy. Enthusiasm for them diminishes when it appears that ignorant consumers may place their health or savings at risk out of ignorance, or when the social costs of poorly informed consumers are high.

The high social costs of poor consumer choices can be illustrated by the following, admittedly extreme example: poorly informed consumers might buy air-conditioners that are much less efficient than ones that would have been purchased with the benefit of an informed analysis of the returns to an investment in higher efficiency. These poorly informed decisions would create a demand for electricity that is higher than would have been the case if all consumers were better informed. This, in turn, could force the construction of a new generating station, for which real returns to capital invested are much lower than the returns that consumers would have earned on added investments in air-conditioners. Leaving all other issues aside, the net result of such a series of events is an inefficient use of national capital resources.

New technologies can help to some extent by making it easier for consumers to sort out information. New information systems could even permit purchasers to play a more active role in designing products and services tailored to their personal needs, and even to receive "on-line" guidance about price trends in products and services of interest to them.

Policy can help improve consumption recipes in several ways:

- Regulations designed to protect consumers, which may have made perfectly good sense when first enacted, may have outlived their usefulness in areas ranging from banking to housing to electric utilities. Many of the specific issues are discussed in the individual amenity network discussions. Three principles, however, seem to have general value in reviewing how regulations might be rebuilt to facilitate the emergence of a more productive, restructured economy:
  1. Arguments about regulations governing the pricing of regulated monopolies, or those governing business entry or exit, need to be kept distinct from arguments about the need to protect consumers against fraud, unsafe practices, or environmental damage. Changing technologies may undermine the logic of regulated monopolies or elaborate programs of cross subsidies, but increase the need for government inspection and safety controls.

2. Subsidies for low-income groups are commonly used to justify regulation of transportation, housing, communications, and other major parts of the economy. They may, however, be inefficient ways of allocating public funds when a large portion of the subsidy does not end up helping the poor.
3. Standards for public regulation of hazards in the environment vary widely. High standards are set in one area (e.g., mobile source emissions), while other problems (e.g., indoor air) are largely unregulated. Contaminants in some kinds of foods are held to very low levels while others are more loosely regulated. In neither case does the response seem to correlate with levels of risk. It would be useful to have a uniform way to measure environmental exposure and associated risks from all sources—food, water, and air. There has been no comprehensive assessment of environmental regulation parallel to the omnibus review of the penal code that occurred several years ago.

- Labels can provide consumers with information not otherwise available for making intelligent choices. Energy efficiency labels on air-conditioners encourage consumers to consider energy costs when making an investment decision, much as miles per gallon labels help consumers make choices about cars. Warning labels on cigarettes and nutrition labels on food products also help in this process. There are many areas where labeling to give quality ratings could be improved, ranging from food products—where information about cholesterol, alcohol, sodium, saturated fat, and pesticide residues appears only voluntarily—to houses, where precise information about energy efficiency and other quality features is extremely hard to obtain.
- Personal income taxes strongly affect consumer incentives, by doing such things as making investments in houses (of any size) more easily deductible than investments in education. These priorities could be reviewed.
- The Federal Government, considered a consumer because of the peculiarities of standard accounting practices, can improve the way it makes critical purchasing decisions and can support research designed to improve its own productivity. Government buildings and vehicles are often less efficient than those purchased by the private sector. The U.S. Government, for example, pays more than $1 billion per year to subsidize heating for public housing—structures often having energy bills far higher than necessary. Major government enterprises, such as public education, are not backed by consistent research support or funds for capital investment.

Production Recipes (Chs. 4 and 5)

The term "production recipe" refers to the combination of products and services a firm purchases from other firms. It includes items from both foreign and domestic suppliers, and both capital equipment and supplies.[3]

Producing for the diverse and rapidly changing markets just described requires alert and integrated production networks. These production networks connect many kinds of manufacturing enterprises, service firms, transportation operations, wholesalers, and retailers. The performance of these networks cannot be measured effectively by looking only at the performance of component businesses—the customer sees the performance of the system acting as a whole. A trucking firm specializing in on-time delivery of comparatively small batches may seem to have lower productivity than another firm with lower charges per ton-mile. Yet the flexibility offered by the more responsive trucking service could reduce costs throughout a complex production and retailing network.

Describing Recent Trends.—Change in the structure of production networks is measured in three ways:

1. *Changes in the recipes used by individual businesses.* Each business creates a product by purchasing inputs from other businesses (materials, capital equipment, business services, etc.) and adds value of its own through the skill of its employees and the capital supplied by its owners (see table 1-2).
2. *Changes in the size of the establishments that comprise the production network, and in their ability to produce more than one product.* Ford's

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[3] In technical terms, the "recipes" considered here include both fixed investment and intermediate inputs.

Table 1-2.—Components of the Production Recipe

Products purchases from domestic producers
+Products purchased from abroad
+Value added
    Capital costs
    Labor costs
    Indirect taxes
=Total value of industry output

SOURCE: Office of Technology Assessment, 1988.

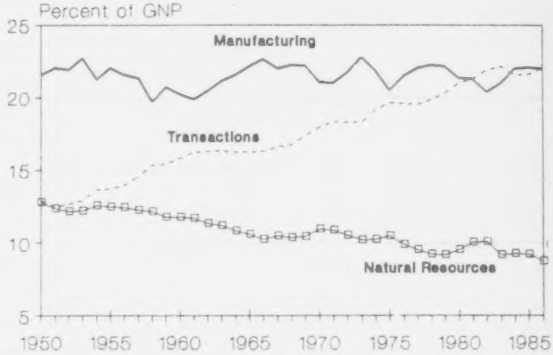
enormous Rouge River plant, which took raw materials in one end and pushed finished cars out the other, seems unlikely to be the model for future production. Instead, production networks are being organized in ways that defy easy classification. This applies to both the size of establishments and the size of firms that may own multiple establishments.

3. *Changes in the geography of production.* Changes in production networks can also be measured by shifts in the physical location of businesses. Changes in recipes, changes in the scale of manufacturing and service enterprises, and a variety of other factors have redefined the logic of firm location.

Changing Inputs.—New technologies, and the complex networks in part made possible by these technologies, make increasingly efficient use of natural resources and energy inputs. The decline in the share of GNP contributed by natural resource businesses (farming, mining, and energy) resulted mostly from a decline in domestic demand for their products (see figure 1-14).

The declining share of natural resource businesses is more than offset by growth in transactional businesses (law, finance, insurance, business services, etc.). Between 1972 and 1984, these gains were almost equally divided between increases in consumer and government demand and increased use of transactional activities as inputs by other businesses (see figure 1-15). The rising use of transactional inputs results in part from increased demands for information, and in part from the fact that the management of these networks has become more complicated—the emerging networks require both more complex external contracting and more complex flows of products and information within firms. The three fastest growing direct inputs into the Nation's production processes are wholesale and retail

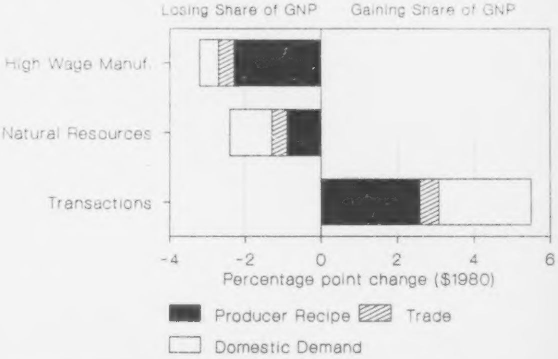
Figure 1-14.-Shares of GNP (in constant 1982$)



How To Read This Figure: Measured in constant 1982 dollars, the fraction of the gross national product contributed by farms, mines, energy companies, and other natural resource businesses fell from 12.8 percent in 1950 to 8.7 percent in 1985. The share contributed by manufacturing appears to have remained close to 22% during the entire period but there is reason to believe that some of the procedures leading to this estimate are flawed (see chapter 5).

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.2 (see figures 5-2b, 5-3b, and 5-4b).

Figure 1-15.-Explaining Changes in Sector Shares: 1972-1984



How To Read This Figure: Between 1972 and 1984 the percent of the U.S. GNP produced by Natural Resource businesses fell 2.4 percentage points. Changes in household and government demand reduced the share by 1.1 percentage points, changes in trade reduced the share by 0.4 percentage points, and changes in the production recipe of businesses reduced the share by 0.9 percentage points.

SOURCE: Office of Technology Assessment (see table 5-1 of ch. 5).

trade services, business services like advertising and consulting, and communications.

While the contribution of manufacturing appears constant in figure 1-14, its share of overall employment has been falling rapidly. Calculations showing that manufacturing commands a fixed share of the GNP, however, depend heavily on techniques used to adjust for inflation. Half of the growth in manufacturing's contribution to GNP estimated for the 1980-86 period resulted from the difference between the inflation adjustment for computers and other information equipment and the average adjustment made for all U.S. businesses. Techniques discussed in chapter 5 suggest that the part of manufacturing paying the highest wages (such as the automobile and steel industries) may have fallen as a percent of GNP during the past few years, resulting in an overall decline in the share of manufacturing. Deficiencies in available data leave the issue clouded.

International trade had a relatively minor effect on the changing GNP shares of most sectors in the U.S. economy before 1980, but has since had an effect nearly as large as shifts in domestic demand. The negative effect of trade was felt most heavily in manufacturing. Transportation, wholesale and retail trade, and transactional services all benefited from trade because many of these enterprises gained business from exports.

There is no good index for measuring the growth of networks. One way is to see how much business a firm generates for its suppliers. An economy-wide index of linkage based on this concept increased 5 percent between 1972 and 1980.

While the entire economy became more tightly linked during this period, conflicting forces are at work. The links connecting manufacturing firms to the rest of the economy, especially to the service sector, seem to be growing: the linkage index for manufacturing industries paying the highest wages increased 15 percent between 1972 and 1980. On the other hand, the transactional businesses gaining share in the economy are not very highly linked to other parts of the economy, since a large fraction of their sales result from their own "value-added" (rather than from the cost of inputs purchased from other firms). On average, manufacturers keep only about one-half of the value of their sales in the form of profits or wages paid to employees—paying the rest to their suppliers. In contrast, service firms keep nearly two-thirds. Service businesses are linked to the rest of the economy primarily through purchases of capital goods, such as buildings and computers. In 1984, demand for manufactured goods generated approximately 6.3 million service sector jobs—about 1 out of every 11—while demand for service products indirectly created about 4.3 million manufacturing sector jobs—about 1 out of every 5.

Changes in Scale and Scope.—Given the striking transformations underway in production networks, it is not surprising that many traditional management strategies are under intense scrutiny. The prevailing wisdom about the optimum size of production facilities, relations to domestic and foreign suppliers, and investment in research and new production technology is being challenged across a broad front. As expected, responses from established management vary from enthusiasm to intransigence. In some cases it seems to swing wildly from one pole to the other.

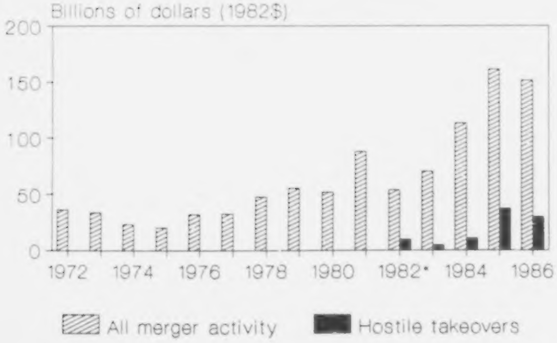
There is much debate, and no convincing data, about the kinds of business structure that will prove most successful in the emerging economy. Indeed the very vocabulary available for describing the different formal and informal business networks and management strategies being tried proves to be inadequate. It is obvious that an enormous amount of experimentation is underway. Many large firms are adopting a management style that allows subsidiaries to act with greater independence. It is common to find many establishments owned by a large firm that provides services such as communication networks, billing, advertising, and personnel management. Clusters of small firms can operate under the umbrella of a larger firm (e.g., suppliers to computer industries).

Under the pressure of intense domestic and international competition, the marketplace should soon provide some clarifying signals. In the meanwhile, there is great confusion over whether smaller enterprises are more flexible, more innovative, more likely to invest in long- or short-range research and development, or more likely to be attractive places to work than larger, more bureaucratic institutions. Economies of scale in individual establishments appear not to be as much of an advantage as they once were. Indeed, there appear to be diseconomies if establishments become so large than management loses touch with employees. Rigidly managed larger firms have suffered from an inability to move quickly to exploit new market niches and new production technologies. In their attempts to impose uniformity, such firms may be unable to learn from their employees. On the other hand, the larger firms can sustain major development projects requiring large, long-term investments. They can also be better employers, offering employees more benefits and more job stability.

One measure of the rate of restructuring can be found in the surge of mergers, takeovers, and divestitures that have taken place in the past decade, made possible by reduced regulatory restrictions (see figure 1-16). Hostile takeovers represented only a small fraction of the total. The net result of mergers, and of patterns of new business formation and bankruptcy, has been a change in the size of the average U.S. establishment and in the range of products that it produces.

Management styles seem to be converging across the U.S. economy. Large farms, for example, are being managed as sophisticated, heavily capitalized enterprises. The owner is often, in effect, a professional manager. The construction industry is increasingly resembling a manufacturing enterprise, with more components assembled in factories. Fragmented "low-technology" enterprises, such as those found in the textile and apparel industries, are becoming consolidated and are coming to depend heavily on advanced production technology. Large integrated facilities, such as those in automobile production, are moving toward smaller establishments and shorter production runs. Large banking and insurance businesses are investing heavily in computer and communications equipment. Hospitals and groups of physicians are moving toward professional management, with physicians as paid employees. Schools may move toward a more differentiated teaching staff and increased capital investment.

Figure 1-16.-Mergers and Takeovers, 1972-86 (constant 1982$)



How To Read This Figure: In 1986, the value of mergers and takeovers totaled more than $150 billion (1982 dollars), up from $40 billion (1982 dollars) in 1972. The value of takeovers considered hostile totaled about $30 billion in 1986.

*Data for hostile takeovers not available prior to 1982.

SOURCE: Julius Allen, "Corporate Takeovers: A Survey of Recent Developments," U.S. Congressional Research Service report No. 87-726-E, Washington, DC, Aug. 6, 1987; and Carolyn Kay Brancato, "Merger and Acquisition Activity: The Level of Hostile Mergers," U.S. Congressional Research Service report No 87-507 E, Washington, DC, June 16, 1987 (see discussion in ch. 5).

In 1984, 73 percent of all manufacturing employees worked in establishments employing more than 100 people, a 2.3-percent decline from 1982, while only 40 percent of employees in finance, insurance, and real estate worked in establishments with more than 100 employees (up 3.2 percent). Nevertheless, enterprises with fewer than 100 employees added 47 percent of all jobs gained by the economy between 1976 and 1984, even though they supplied only 37 percent of all jobs in 1976. The largest gain in employment share between 1978 and 1982, however, was in small establishments of large enterprises.

While small firms have generated a growing percentage of all jobs, they appear to generate a decreasing share of output. Businesses with 20 to 500 employees increased their sales annually by 4.3 to 9 percent between 1976 and 1982, while firms with more than 10,000 employees grew at 16 percent. Part of this growth can be attributed to recent acquisitions and mergers. The strategies behind the mergers are frequently difficult to ascertain since most recent mergers have been classified as "conglomerates," a category that includes both mergers made to achieve system-wide productivity gains and mergers that represent portfolios of convenience for speculators. While only 50 percent of mergers were classified as conglomerate in 1950, 90 percent were classified this way in 1979.

Mergers tend to make the parent firm more diverse. Between 1963 and 1982, the number of different products made by a single manufacturing firm increased 15 percent. At the same time, establishments that are a part of larger firms have become more specialized. The number of different products made by single manufacturing establishments declined by a factor of 3 over the same period.

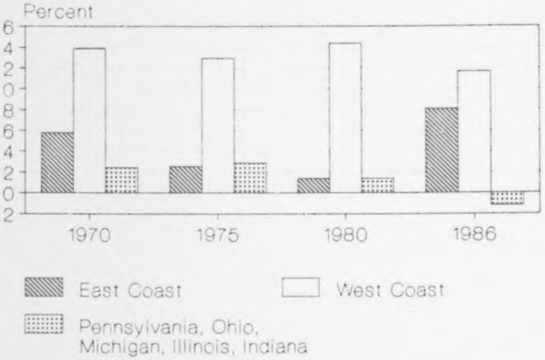
The Geography of Production.—A map showing such natural features as rivers and harbors, or even minerals, no longer says a great deal about where economic activity will occur in the United States. New forms of communication, declines in the scale of individual establishments (in both manufacturing and services), a decline in the resource demands of manufacturing, movement of jobs from the shop floor to offices, improved flexibility and responsiveness in transportation, and a variety of other factors remove many of the constraints that formerly limited choices about business location.

The theoretical possibility of locating a manufacturing or back office service firm virtually anywhere has, however, apparently been more than offset by other factors. The attraction of locations offering a well-educated labor pool (even where this means higher taxes), and access to major research centers and financial institutions, increases as other constraints on location diminish. A survey of "high technology" manufacturing firms taken in 1982 indicated that "access to raw materials" was 12th in a list of 12 reasons for selecting a plant location. The availability of skilled labor topped the list, ahead of concern about labor costs. Moreover, rapidly expanding businesses, such as banking, insurance, law, and real estate, still depend on networks of personal contacts and communications. This often translated into a decision to locate new facilities in the immediate vicinity of urban centers: New York, San Francisco, and more recently Los Angeles, Dallas, and Houston. The excitement and variety of these areas are plainly also a lure.

The result has been an increasing concentration of employment, particularly high-wage employment, around major metropolitan areas of both coasts (see figure 1-17). Indeed, there has been rapid movement of economic activity down the east coast, from Boston to Miami; continuing expansion in Texas, Arizona, and southern California; and continuing losses of population and economic activity in the rust belt regions of the northern midwest.

While inequalities in regional incomes declined during the 1970s, the decline appears to have stopped. In fact, during the 1980s New England and the Pacific coast regions appear to have regained their significant lead in average incomes. Incomes in Ohio, Illinois, Indiana, Michigan, and Wisconsin, which were above the national average in 1970, are now below average. Although they remain below the national average, incomes in States on the southern Atlantic coast showed a steady gain from 1970 to 1985. The southern Appalachian and Gulf Coast States, however, have incomes that remain 20 to 25 percent below the national average—a position unchanged since the 1960s. On the whole, the economies of the U.S. coastal States appear to be prospering, while the center of the Nation falters.

Figure 1-17.-Regional Wages: Percent Above or Below National Average



How To Read This Figure: In 1986, wages in States bordering the Atlantic coast were 8.1% above the national average and wages in States bordering the Pacific coast were nearly 11.7% above average.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "Regional Economic Information System," tables SA1, SA2, and SA3, unpublished, August 1987 (see discussion in ch. 5).

It is difficult to account for the continuing attractiveness of coastal cities and the failure of U.S. companies to move to low-wage regions. Employers appear to be willing to pay a premium for access to people with good training and job skills, and use their new mobility to pay lower wages to relatively well-trained people abroad. An employee in Taiwan with a solid high school training in mathematics, for example, costs far less than a person with a mediocre education in the United States.

With the exception of New York, most of the growth has occurred in centers associated with a major city but not in the traditional core of the city. Population shifts to the suburbs have allowed many people to live in relatively inexpensive areas while keeping commuting times reasonable. However, this has also made public transportation virtually impossible. And since the headquarters of most major firms are usually located in downtown areas, movement to suburbs may have blocked contacts critical for career advancement. Suburban business growth can also create problems for mid-level minority workers, many of whom cannot afford to live in suburban areas and are unable to commute there on public transit.

Population has followed economic activity, and Americans remain extremely mobile. Only half of the population lived in the same house in 1985 as in 1980, and one-third had moved from a different U.S. county or a different country. A survey of movers in the early 1980s indicated that the 50 percent moved to take a new job or military assignment. Nearly one out of every six people classified as "displaced" between 1981 and 1985 moved. Surprisingly, the highest percentage of displaced workers who moved were not the youngest workers but those aged 45 to 54.

Strategic Choices.—It is apparent that a deep structural transformation is taking place in production networks. Trends are difficult to read because of complex patterns of experimentation. The challenge of policy here is to create a system of rules that encourages experimentation, transformation, and growth without sacrificing the traditional responsibilities of government to provide protection against monopoly abuse and protection for individuals and communities forced to bear the burden of adjustment.

The challenge is to find practical ways to enjoy the advantages of competition and "creative destruction" in fostering change, while minimizing the risk that such a process will destroy the ability to engage in long-term development work. There is no magic way to do this. The most promising places to look for solutions are first in the financial rules that guide investment decisions, and second in research and development policy.

Financial Rules.—The rate at which constructive changes are made in production networks, as well as the kinds of networks created, depend heavily on the financial rules under which investors operate. Typically, failure of the U.S. financial system does not occur in its support of invention or innovation. The United States continues to lead the world in many research fields, and has a strong venture capital community. Problems seem to develop when hundreds of millions of dollars must be found for comparatively risky projects that require many years to reach maturity; in effect, the system seems to fail once the invention in the garage starts working. Public policy in areas like tax law, as well as the techniques used to evaluate managers, can influence the planning horizon of investors and businesses. Some financial instruments are obviously keyed to very short-term, speculative trading that is only weakly tied to the long-term interests of a firm. On the other hand, the pressure of aggressive financial markets is necessary to ensure effective management of national capital assets. Takeover threats and the potential for stockholder rebellion can provide a defense against inattentive management.

The following policy options may improve the mix of patient capital and effective competition for capital resources:

- Tax reform:
  - —reduce or abolish income tax paid on capital gains from assets that are held for more than 3 years;
  - —limit the deduction for housing interest to a fixed amount;
  - —reform or abolish the corporate income tax (it contributes only 7 percent of government revenue; its complexity distorts private investment decisions; the transactional costs associated with tax compliance are high; the tax acts as a non-progressive sales tax for U.S. consumers; and it increases the cost of U.S. exports).
- Reform of the system regulating financial institutions (limitations on merchant banks, for example), which could allow for greater diversity in capital assets available to corporations and could encourage more long-term plans for new products and production networks.
- Reduction of transactional costs, by developing better techniques for combining regulation, negotiation, and freedom to sue for damages.
- Review of priorities for the $200 to $300 billion in federally supported loans and loan guarantees now largely directed to housing and agriculture.

Research and Innovation.—A competitive and prosperous economy depends both on a system of incentives that encourages investors to make money from new ideas, and on a continuous supply of new ideas; neither is adequate in itself. Research and innovation play a growing role in the health of every sector in the economy. Even areas where research has not traditionally played a major role (e.g., home construction and apparel) are likely to find their productivity and competitive position strongly influenced by the ability to conduct and absorb the products of research. It is essential that the United States improve on the way it combines corporate and public resources in the pursuit of innovation. Like education, this is an area where government expenditure should be considered as investment and not consumption.

There are many areas of pure research that cannot be sponsored by corporate funds because of the high risks involved. Also, areas of applied engineering can play a crucial role in national economic development, but their value is likely to be spread so broadly that no firm can expect to regain its investment in full.

The challenge is to find ways of spending public funds in a manner that neither competes with existing private innovation nor disappears in pursuit of white elephants. Two basic strategies deserve attention:

1. *Cooperative Research Facilities.* Measured in terms of the development of inventions that have provided a key to world economic growth, Bell Laboratories surely was one of the best research facilities in the history of the world. It has, of course, been largely reorganized following the breakup of the AT&T system. A variety of mechanisms have been proposed for building laboratories of this quality around clusters of pure and applied research issues:
    a. a mechanism for mingling public and private funds in ways that allow public disclosure of discoveries affecting the common interest, while permitting private firms to maintain rights to specific proprietary ideas;
    b. a reputation for research excellence that would attract the best people in the field (it may be necessary for the facility to be associated with a degree program at a major university);
    c. research freedom adequate to permit exploration of novel ideas, coupled with a set of general themes tied to practical markets;
    d. a way to disburse funding through grants and venture allocations to small research groups;
    e. a way to combine academic research with research keyed to practical needs that does not compromise the intellectual freedom of universities; and
    f. a way to encourage research capable of improving productivity in business services (since service productivity is of growing importance to overall economic growth).

    The Bell management provided guidance on the balance between pure and applied research. Research ventures pooling resources from many firms could be managed by a private board with an interest in seeing that funds are well used.

    A number of sectors of the economy do not conduct significant amounts of research and might benefit from a coherent research program, such as new technologies for learning and teaching, residential construction, and textiles and apparel. Government itself is a major information enterprise, and could justify research designed to improve the net efficiency of data processing and communication within its own bureaucracy. This, coupled with a careful procurement policy, could work to stimulate efficiency in private firms and to encourage new information technology.
2. *National Goals.* Research in some areas could be stimulated by the clear articulation of a national vision—a goal with the power of the space program that could be accepted as important by all Americans. Candidates include a Learning Research Institute, the renewal of space exploration, or even the development of a radically new form of personal transportation. Such projects are, by definition, impossible to justify on the basis of a purely rational calculus of cost and benefit. But they can couple public imagination and support of private genius in ways not otherwise possible. Properly constructed, the project could provide a home for a variety of research efforts and a market for many of the products of research. Defense-related projects can focus research efforts, but they may not be an adequate substitute; security classification, specialization in areas without clear commer-

cial applications, and other factors limit the extent to which defense research facilitates opportunities for civilian economic growth.

International Connections (Chs. 7 and 8)

Describing Recent Trends.—Production networks have always operated across international borders. In the past two decades, however, the networks connecting the United States to the rest of the world have changed in both size and scope. Nearly 7 million American workers now owe their jobs to exports, a percentage that has nearly doubled in a decade. Because of the large trade imbalance, however, U.S. employment might have been 10 percent higher in 1984 without imports.[4] Figures 1-5 and 1-6 showed that trade has entered virtually every production network and has had a significant impact on virtually every U.S. business. The few areas that are not already involved heavily in trade (home construction, for example) may soon find themselves parts of international production networks.

If nothing else, trade creates direct competition between American styles for managing networks and those of other countries. Until very recently, it could comfortably be assumed that American firms would be at the lead in development of new products and labor-saving technology. America led the world in both supplies and demand for innovation. American commitment to research and innovation was strong, and America had the most affluent consumers and most expensive labor. Forces driving both supplies and demand, however, have changed rapidly during the past few years.

The ambiguity about whether new technology would encourage geographically dispersed production networks in the United States (as seems theoretically possible), or would lead to further concentration in favored regions translates directly to ambiguity over the effect of technology on trade. In some cases, technology has encouraged the spread of economic activity:

- The complexity of production networks, and the decline of large production establishments, has allowed more points of entry for foreign products.
- The declining significance of resources, and the growing importance of a firm's ability to manage innovation, has made it possible for alert and aggressive foreign firms to compete successfully in U.S. markets.
- Communication and efficient transportation of lightweight, high-value products makes it possible to tie diverse networks together. Advanced telecommunication equipment has created worldwide financial networks.
- The previous discussion showed how technology can affect the scale of production. It proves difficult, however, to demonstrate the effect of scale on international competition. Anecdotes can be provided showing how small, entrepreneurial U.S. firms have fallen victim to large, patient, bureaucratic foreign organizations (e.g., producers of semiconductors). Examples can also be found where small, aggressive foreign firms entering U.S. market niches have beaten bureaucratic firms in the United States (e.g., manufacturers of textile machinery).

There are also reasons to believe that technology may undermine trade and exaggerate, rather than shrink, the difference between living standards in rich and poor nations:

- Technology capable of making efficient use of energy and material resources can limit needs for world trade in these products.
- Technology capable of making small batch production nearly as efficient as large mass production can reduce the advantage of large plants producing for world markets.
- The growth of niche markets, and of domestic production networks requiring rapid movement of products between establishments, can increase the advantage of proximity.
- Networks connecting retailers and producers in ways that minimize inventories depend on an ability to respond quickly to changes in markets—this increases the value of producing in locations physically close to the market served.

Changing Comparative Advantage.—Under ideal conditions, the economics of trade should encourage each nation to specialize in the production of goods and services that its firms make at *comparatively* low cost. If the ratio of exports to imports of a given product decline, trade may have revealed a decline in the nation's comparative advantage in that product or service. While real international markets fall far short of the ideal markets that in theory would reveal comparative advantage, since national policies frequently shape trade patterns, it is useful to see what the record shows about changes in America's comparative position in different areas.

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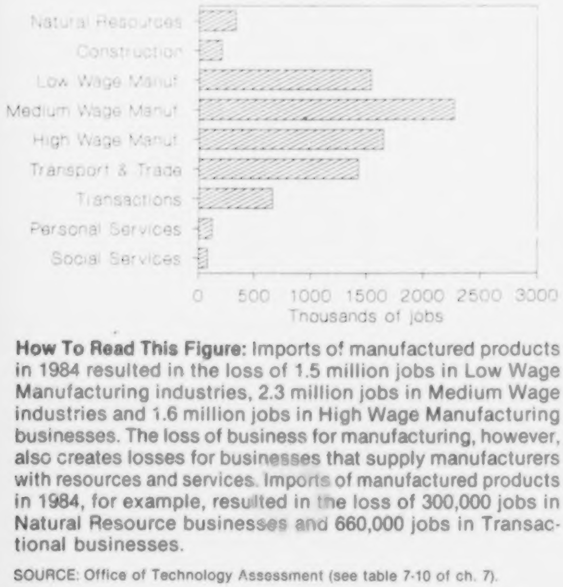
[4] These estimates, and many that follow in this summary, are based on an input/output analysis approach discussed in chapter 7. They must be treated with great care. Obviously, it is difficult to estimate how the economy would operate without imports since the price of domestically produced items is different. Assumptions needed to make the estimates, and the limitations of the methods, are discussed at length in chs. 4 and 7.

Trade forces attention to the links connecting different parts of production networks. Figure 1-18 shows, for example, that a significant fraction of all jobs hypothetically lost from U.S. imports of manufactured products in 1984 were lost in service enterprises that played a role in production networks. About 1.5 million jobs in transportation and trade and over 600,000 jobs in transactional activities were lost indirectly because imports displaced domestic manufacturing activity. All told, 4 of every 15 jobs hypothetically displaced by imported manufactured goods are in the service sector.

Figure 1-18.-The Jobs Lost Because of Imports of Manufactured Products in 1984 (illustrating trade linkages)



How To Read This Figure: Imports of manufactured products in 1984 resulted in the loss of 1.5 million jobs in Low Wage Manufacturing industries, 2.3 million jobs in Medium Wage industries and 1.6 million jobs in High Wage Manufacturing businesses. The loss of business for manufacturing, however, also creates losses for businesses that supply manufacturers with resources and services. Imports of manufactured products in 1984, for example, resulted in the loss of 300,000 jobs in Natural Resource businesses and 660,000 jobs in Transactional businesses.

SOURCE: Office of Technology Assessment (see table 7-10 of ch. 7).

Considering both direct and indirect effects, trade appears to have reduced business for nearly all U.S. "high technology" production between 1972 and 1984. Chemical products was one of the only industries that gained in relative rank between 1972 and 1984, while businesses in electronic components, office and computer equipment, engines, aircraft, and other technology-sensitive industries lost rank. In general, 18 of 20 industries designated as "high technology" lost rank over this period. Businesses with heavy natural resource components (i.e., lumber, leather, tobacco, and paper) gained rank, as did service and support businesses.

Measured from the perspective of occupations gaining or losing advantage from trade, manufacturing employees lost in comparative terms between 1972 and 1984 while lawyers, communication equipment operators, and farmers gained rank. Of all "hand working," "machine setting," and "precision production" jobs in 1984, 23 to 32 percent were displaced by imports. These occupations, however, also gained the most from exports, with 12 to 17 percent of their 1984 jobs resulting directly or indirectly from exports. The period showed a sharp break between the way engineers and scientists were affected by trade. Scientists benefited from changes in trade, while engineers were among those most heavily disadvantaged. Had all imports that could be manufactured in the United States in 1984 been so manufactured, there would theoretically have been 21 percent more jobs for engineers. On the other hand, 14 percent of U.S. engineers owed their jobs to exports. Natural scientists, computer experts, and mathematicians were less heavily affected, with a 12 percent loss from imports and an 8 percent gain from exports. The occupations least affected by trade were in services (i.e., teachers, health services, clericals, and sales personnel).

Strategic Choices.—It is theoretically possible for trade to improve living standards throughout the world, but this promise remains clouded by the stubborn realities of nationalism, protectionism, and distrust. The central objective of trade policy must be to make trade a positive sum game for all participants, including the United States.

Even in the best of circumstances, the theoretical advantages of free trade can be demonstrated only for the average American over the long-run. There will be winners and losers as trade expands production networks across international borders. A second objective, therefore, must be to find ways to share the pain and the advantages of trade as widely as possible. At a minimum, no group should bear the bulk of the burden of adjustment.

It is worth beginning by being clear about some of the problems associated with trade even under favorable circumstances:

- Expanding trade increases the difficulty of managing the domestic economy without international cooperation.
- Expanding trade takes jobs from the individuals with the lowest skills in the United States, and increases uncertainty throughout the economy. Trade has a comparatively large effect on those with poor educations. In the economy as a whole, one job in five is held by a college graduate. Only one job in seven lost to trade, however, is lost by people likely to have college degrees.
- Statistics underestimate the disruption caused by expanding trade, since the jobs created by exports are not necessarily in the same companies, or located in the same place, as the jobs lost due to imports.
- Foreign producers able to expand their productivity rapidly may have a significant short-term advantage in crucial areas before wages in their home countries increase to reflect productivity growth. New or infant industries may be hurt by foreign targeting, although with rapid economic change, successful businesses prosper by being perpetual adolescents.
- A productive and innovative domestic economy is essential for national security—particularly in areas where the United States relies on technical advantages rather than on advantages growing out of higher levels of spending or manpower.

The most important tool for improving the U.S. trading position is clearly the restoration of leadership in areas critical to America's export performance, as well as productivity gains in manufacturing. Indeed, manufacturing exports are likely to be the only way that the United States will avoid massive trade deficits in the foreseeable future. But improvements in domestic productivity alone are unlikely to be adequate in a global environment where explicit manipulation of trade by foreign governments is the norm.

To have any positive effect, management of trade must be patient and skillful. Under present circumstances, unilateral steps taken even by the largest economy in the world are unlikely to be effective. Only multinational action is likely to move constructively toward this objective.

U.S. leadership is of vital importance. This leadership can grow only from a coherent strategy built around a clear set of objectives and from skillful and patient negotiations in a variety of international forums. Finding a way to put the U.S. trade and spending accounts in order by shrinking the deficits in government budgets and trade accounts is an essential first step.

The following options deserve consideration:

- Banking and fiscal policies among nations belonging to the Organization for Economic Cooperation and Development (OECD) could be coordinated in fact, not just in rhetoric, to ensure that such policies are not working at cross purposes.
- Policies coordinating international development assistance and trade policy in the OECD could ensure the economic growth in the third world necessary for a long-term solution for their debt problems.
- Domestic policy decisions could be scrutinized more closely for their effects on the U.S. trading position. Prior to the post-war era, trade played such a small role in U.S. business transactions that public choices in critical areas, ranging from telecommunications to banking to agriculture, were made with little attention to the impact of these choices on the competitive position of U.S. firms—or, in the case of telecommunications, to the impact of opening U.S. markets to foreign competition without obtaining reciprocal opportunities for U.S. suppliers to enter foreign markets.
- Cooperative research programs in areas of clear mutual interest could be expanded. There are many areas where the combined world benefit of having a problem solved rapidly is far greater than the short-term gain that any single country could enjoy by reaching the goal first. Breakthroughs in medicine or safety for a variety of

industrial operations would be mutually beneficial.

- Tariffs, rather than non-tariff barriers, could be used when temporary protection is warranted. Tariffs maintain price competition and the value of the higher price paid by consumers remains in the United States, whereas quotas allow benefits of price increases to flow primarily to foreign suppliers—thereby enabling them to further improve their long-term competitive position and expand their markets.
- A variety of programs in export promotion could help businesses unfamiliar with the complex world of international markets find outlets for their products. Many of the Nation's competitors have far more sophisticated systems than the United States in this area. Information alone can help. The Department of Agriculture, for example, has introduced a successful data network that assists comparatively small farming operations in bidding on foreign solicitations.
- Increased language training, translation, and education about the culture of U.S. trading partners could help U.S. exporters understand export markets and more easily penetrate the labyrinth of foreign marketing problems.

People in the Production Recipe (Chs. 10 and 11)

The cycle suggested in figure 1-2 connects people in their role as workers and investors to people in their role as consumers. Some of these people know each other. Some are connected only by passing products to each other, and some are connected through paper flows and electronics. Figure 1-7 provided a crude description of how these networks operated in 1984.

Capital invested in new technology, and the way management chooses to use this technology, has the potential to reshape these relationships in very basic ways. Specifically, information technology has the ability to mechanize tedious and repetitive intellectual tasks in much the same way that farming and manufacturing equipment mechanized tedious and repetitive physical tasks. Many of the jobs being created in the emerging economy do not appear in conventional categories. While the "labor" part of many tasks proves comparatively easy to automate, the part of a job that requires imagination, a capacity for learning, or an ability to work with other people is not easy to automate and therefore represents a growing fraction of all jobs.

The new networks can make the links connecting a person's daily work and a job's contribution to human welfare more transparent. This can mean that an apparel worker operating as a part of a responsive team tailors batches of products for specific clients instead of doing repetitive mass production. It can mean an insurance "para-professional," discussing policies with a customer on the phone and entering data into a terminal rather than keypunching anonymous data. It can mean a teacher having more time to spend with individual students.

Productive use of new technologies will require deep changes in management strategies and job descriptions in areas as diverse as insurance, education, health, and apparel production. These changes in turn can undermine long-standing assumptions about the role of people with different skills, the power commanded by different groups, the role of managers, the factors that motivate work, and the links connecting pay with skill. Some connections can be explained using the economics of "human capital." The networks are obviously also connected by pride, loyalty, prejudice, compassion, whimsy, love, and many other factors not measured by bookkeepers.

For better or for worse, the influence of all these factors is likely to be reshaped as production networks are transformed. The impact is enormously important but impossible to measure. Systems based on one kind of prejudice or irrationality may well be replaced by systems based on others. The task of management is changed when jobs become less precisely defined or when the job definitions themselves are changing. This can mean that the bargaining power workers have achieved on the basis of unique skills will be diminished, and that employers will have difficulty developing satisfactory techniques for measuring individual contributions.

Education is likely to play a central role in determining who is advantaged and disadvantaged by structural change. Education seems important not just for making a person productive as a member of a team with a fixed purpose, but also because it helps people learn and change to keep pace with dynamic production networks.

Since little is known about the merits of different approaches to using much modern production and information equipment, there is little certainty about the kinds of jobs that should be created. Radically different strategies are possible:

- It appears possible to create efficient production networks basing their performance and flexibility on the intellectual and social skills of employees.
- It is also possible to envision a system where a well-educated elite enjoys a majority of the benefits, while the costs of flexibility are paid by workers forced to take temporary jobs with narrowly defined tasks monitored by electronic surveillance.

While it is possible that the second of these alternatives would prove most effective in a highly competitive economy, a wealth of anecdotes suggests that it would not. Choices made in the next few years can play a critical role in shaping the outcome. Policy designed to capture the first of the alternatives must accomplish two things, neither of which is adequate in itself: first, it must ensure an adequate *supply* of well-trained individuals (meaning education available throughout a person's career); and second, it must ensure a productive and innovative economy capable of providing jobs that can take advantage of a skilled work force.

Describing Recent Trends.—While changes in the structure of the economy are changing supplies of new jobs, the entry of the baby boom into the work force, the rapid growth of women in the work force, a move toward early retirement for older men, and a new wave of immigrants have changed the "supply" of skills and experience in the work force. There has also been a change in the racial composition of the work force. An absolute majority of all people joining the work force between 1985 and 2000 will be minorities, many of whom will enter with comparatively poor educations.

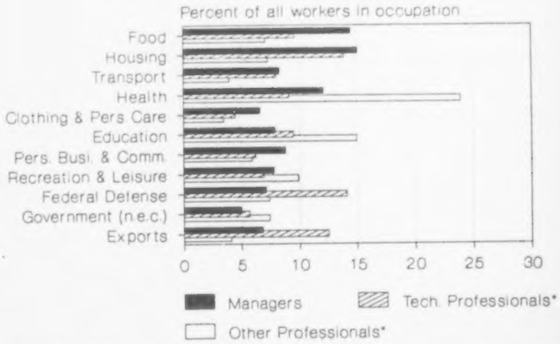
Changes in the role played by transactional, manufacturing, natural resource, and other business sectors translate directly into changes in their share of U.S. employment. The effect is magnified by differences in the rate of growth of labor productivity in each sector.

In part because of the comparatively rapid growth in productivity, the proportion of manufacturing jobs in the economy has declined—from 27 percent of all full-time equivalent employment in 1950 to 18 percent in 1986. Over the same period, jobs in business services and related activities grew from 6 to 15 percent. Changing demand and changing regulations were largely responsible for the sharp increase in health care, education, and other government employment during the 1950s and 1960s, and for their relatively unchanged share of national employment since 1975.

Changes in production recipes, and even changes in the overall number of people a firm requires to produce its products, explain only a small part of the radical change in occupations emerging in the economy. Many of the new jobs fall into unfamiliar categories. This is particularly true in areas where information equipment has transformed processes and management strategies. Awkward terms like "para-professional," "para-librarian," and "super clerk" are used to bridge the gap between old paradigms about job categories and ones that remain to be developed. Professions like "teacher" are likely to be transformed into many identifiable specialties in the next few years.

Since figure 1-7 contains all the jobs in America, it is possible to follow the contributions of different jobs to their ultimate contribution in the form of amenity. Figure 1-19 shows, for example, that jobs for natural scientists, engineers, and other technical professionals are heavily concentrated in Defense and Exports. Law-

Figure 1-19.-Where Managers and Professionals Contribute Value*



How To Read This Figure: Nearly 15% of all managers and 9.6% of all technical professionals in the U.S. are employed directly or indirectly in the process of producing Food for domestic markets.

*Not including education and health professionals.

SOURCE: Office of Technology Assessment (see table 10-6 of ch. 10).

yers, social scientists, and other professionals are concentrated in Health, Education, and Recreation.

Looking at the national statistics, managers and professionals were responsible for nearly 40 percent of net jobs added between 1972 and 1986 (see figure 1-20). Undoubtedly, many are doing tasks that would have been handled by clerical personnel in an era where entering and thinking about data could be clearly separated. Jobs in sales, administrative support, and services (other than household or protective services) also increased sharply, while there was a net decline in the number of persons holding jobs as laborers, fabricators, and operatives.

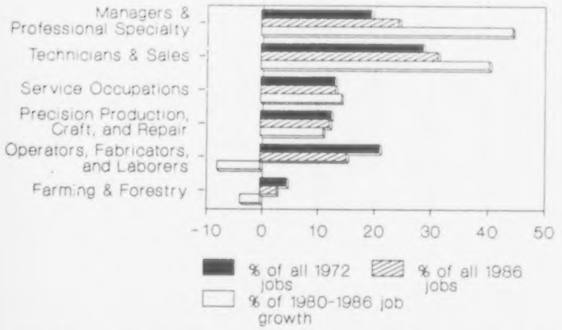
Changes in the scale and scope of firms and establishments that form parts of production networks, and changes in the scale and scope of work teams within individual establishments, obviously reshape the nature of work and the kinds of jobs required. Occupations once part of rigid hierarchies, like mass production manufacturing, may be redefined if productive use of production equipment requires more independent intervention on the part of operators. Attempts to introduce "mass production" management into clerical work have not enjoyed much success. On the other hand, occupations with a tradition of independence (e.g., teachers, home builders, and physicians) may find themselves in more bureaucratic settings.

The changes in occupations are extremely diverse. It appears, however, that on average new jobs are being created most rapidly in areas that require significant amounts of education (see figure 1-21). Growing unemployment rates among young workers with 4 or fewer years of high school was responsible for a significant part of *all* growth in U.S. unemployment rates in the last decade. High correlations between education and income persist, although the connection between skills learned in formal education and skills actually required on the job may be becoming less clear.

There may be a growing gap separating people able to grow and prosper with economic change from people who, for lack of good education or other reasons, remain trapped in positions with little future. Janitors, employees in fast-food emporiums, farm labor, maids, and a variety of other occupations are likely to represent a large part of the American work force for the foreseeable future.

Changes in Pay and Job Quality.—While a review of changes in the kinds of jobs produced provides one measure of how the new production networks have changed the nature of work, it is also important to see how they have changed the quality of

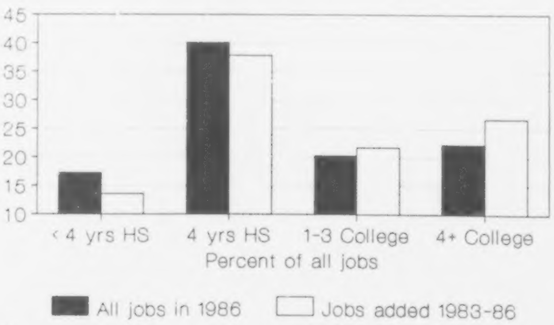
Figure 1-20.-New Jobs and Existing Jobs by Occupation



How To Read This Figure: Managers and Professionals held 19.6 percent of all U.S. jobs in 1972 and 24.5% of all jobs in 1986. About 45% of all job growth between 1980 and 1986, however, resulted from the addition of jobs in these occupations.

SOURCE: Office of Technology Assessment (see table 10-10 of ch. 10).

Figure 1-21.-The Growing Demand for Education (percent of jobs for indicated level of education)



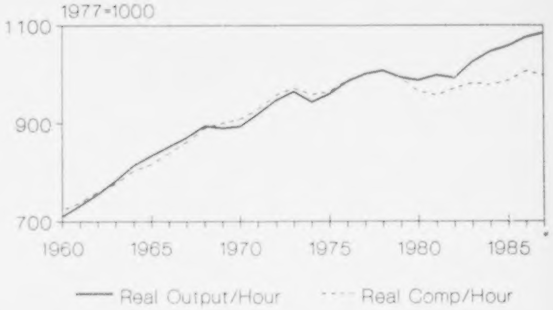
How To Read This Figure: About 22 percent of all jobs in 1986 were held by people with four or more years of college education. Nearly 27% of all new jobs created between 1983 and 1986 were for positions held by people with 4 or more years of college education.

SOURCE: Office of Technology Assessment (see table 11-4 of ch. 11).

the jobs created. Job quality can be measured in a variety of ways: (a) the wages and benefits paid; (b) the equality in allocation of wages and benefits (it is entirely possible for the average wage to grow while the real wage of many employees falls); (c) the extent to which working hours can be adjusted as needed to combine work with raising children, an education, or partial retirement, while maintaining the security of the job; and (d) the extent to which a job provides non-cash rewards in the form of self-fulfillment, pride, and fun. Each of these ways of measuring quality require a different approach.

(a) Changes in the *wages and benefits* paid in American jobs are filled with paradoxes. Real hourly wages for non-supervisory production workers have not increased for 15 years while real GNP per capita has grown almost constantly. Employee compensation increased at almost exactly the same rate as productivity until the late 1970s, but comparatively little of productivity growth since the 1970s has been passed to employees in the form of increased compensation (see figure 1-22).

Figure 1-22.-The New Gap Between Growth in Productivity and Compensation (real output & compensation per hour)



How To Read This Figure: Between 1977 and 1987 U.S. productivity increased 8.4 percent but compensation remained nearly unchanged.

*Preliminary.

SOURCE: *Economic Report of the President 1988* (Washington, DC: U.S. Government Printing Office, 1988), p. 300 (see discussion in ch. 11).

Some of these paradoxes can be explained by the fact that increased international and domestic competition put pressure on U.S. wages. The effect was reinforced by the rapid growth in the work force resulting from the entry of the baby boom. The fall in the fraction of GNP paid as wages and salaries, however, resulted from several other factors. Economic transformation meant that a larger fraction of GNP was needed by businesses replacing equipment. This meant high rates of depreciation and a decline in the fraction of GNP paid as personal income. Non-wage benefits represent a growing fraction of compensation; more personal income was paid in the form of retirement benefits and welfare assistance. Interest, dividends, rents, and other unearned income became a larger fraction of all income.

The many forces at work have made changes in compensation difficult to explain. The industries where compensation increased faster than the average between 1970 and 1985 make a rather curious collection: legal services, the armed services, telephone and telegraph, metal mining, government enterprises (like the Tennessee Valley Authority), motion pictures, health services, and investment companies.

Among other things, new patterns of capital investment have redefined the way wages are paid. Some service industries have invested more money per employee than manufacturing firms since the recession of the early 1980s. Competitive markets, however, mean that these differences are not necessarily linked to wages. High rates of capital investment per worker may actually reduce the skill levels required of workers.

Connections between pay and skill become more ambiguous when the most critical skill offered by an employee may be a capacity to learn new tasks quickly, to perform well in unique situations, and to work well with people. These are "general" skills, rather than "specific" skills that allow workers to benefit from a limited supply.

(b) The factors just discussed, coupled with the shifting pattern of occupations, have reshaped *the way income is distributed*. The wages of men have become somewhat less equally distributed, as have the wages of women. On average, however, the gap separating male and female wages is closing, thereby removing a major source of wage inequality in the work force. The net effect of these changes is that overall wage inequality has not changed significantly. Inequality in compensation has probably grown more rapidly than inequality in wages because the benefits offered for different kinds of jobs differ greatly.

Even if inequality in wages and salaries is not increasing, demographic and other factors are increasing inequality of household income. Growing numbers of households headed by single women, the growing importance of unearned income (which is very unequally distributed), and the fact that high-income people tend to marry each other created a situation where income per household became strikingly less equal during the 1980s.

These and other effects have resulted in a situation where real after-tax income has fallen for more than 90 percent of American households. Some of this has resulted from the decline in family size. Household incomes "per adult-equivalent family member" have increased for most household types.[5] Inequality in household income per family member has, however, also increased during the past decade.

(c) Apart from pay, a worker's ability to *control working hours*, and ultimately the ability to keep a job, is obviously a critical measure of job quality. Two perspectives on this issue are important. Flexibility is important to employees as well as to employers, although for different reasons.

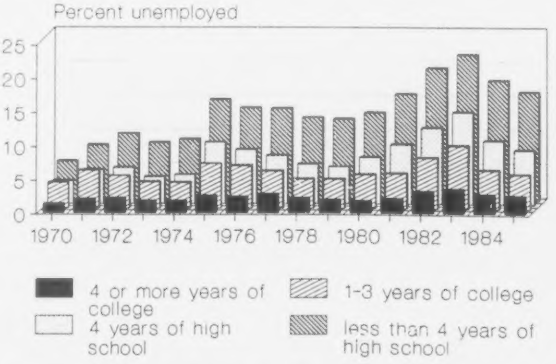
Working parents, students, people in semi-retirement, and people interested in job mobility often find flexibility in working hours an asset. Employers need flexibility to respond to new competitive pressures, business cycles, and to introduce new production schemes. The record on balancing the employer and employee interest in flexibility is mixed.

The search for greater flexibility has caused many employers to minimize commitments to permanent staffs. The number of people working in temporary or part-time jobs has increased rapidly. This is an advantage for some and a liability for others. The key question is the extent to which changes in working hours are under a worker's control. Mothers wishing to work at home, independent owner-operators, self-employed construction managers, and farmers are often willing to trade uncertainty for the sense of independence they can achieve by working for themselves or by themselves. For many, however, the uncertainty is highly unwelcome. The number of women who worked part time involuntarily, for example, increased 300 percent between 1967 and 1984.

Surprisingly few people in the United States hold stable, 40 hour a week jobs. Throughout the economy, temporary, part-time, and self-employed workers increased 25 percent between 1975 and 1985 and now represent 27 percent of the work force. High volatility in employment has always been endured by nonunion employees with comparatively few skills. Temporary employment, however, has become common even for individuals with basic skills. Most of the burden of adjustment seems to be born by people with comparatively poor educations (see figure 1-23). College graduates weather recessions with comparatively low rates of unemployment, while unemployment for high school drop-outs went over 20 percent in the early 1980s. Annual turnover rates for blue-collar occupations may be as high as 20 percent.

While there appears to be some growth in the number of firms attempting to stabilize employment by encouraging wage flexibility through profit-sharing and other means, firms have consistently achieved flexibility in the United States through new hires and lay-offs. This is particularly tempting when firms employ older, comparatively expensive workers with obsolescent skills, while new production systems place a premium on credentials and basic skills that these older workers may lack. It is difficult for a firm

Figure 1-23.-Who Bears the Burden of Change? (unemployment and education)



How To Read This Figure: In 1985, 16% of people with less than 4 years of high school were unemployed but only 2.6% of people with four or more years of college were unemployed.

SOURCE: U.S. Department of Education, Center for Education Statistics, *The Condition of Education* (Washington, DC: U.S. Government Printing Office, 1986), table 2-3 (see discussion in ch. 11).

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[5] An adult-equivalent counts children as a fraction of an adult. See ch. 11 for a further discussion.

to justify retraining when workers with adequate training are looking for work, and when the costs of training can be lost if an employee leaves a job to work elsewhere.

The shifts in occupation by industry are painfully visible in statistics on experienced workers who lost their jobs between 1981 and 1986 because of plant closings or lay-offs. Of the 5 million people unemployed due to these factors, half had worked in manufacturing, where nearly 1 job in 8 was eliminated. The service industries were virtually untouched. In spite of the severe recession of the early 1980s, only 2 percent of people working in finance, insurance, and real estate, and only 4 percent of the workers in business services, were displaced. These businesses added jobs throughout the 1980s.

Workers displaced by economic restructuring faced a difficult period of adjustment. Of those displaced between 1981 and 1986, less than one-third were reemployed with salaries equal to or greater than their previous jobs. Nearly half failed to find full-time employment. Displacement hit older workers with particular force; less than half of displaced workers over the age of 55 had any kind of employment in 1986.

(d) However important, there is plainly no good index for non-cash rewards of working life. As earlier discussions indicate, there appears to be an enormous range of possibilities in the character of the jobs created by emerging production networks. It is clearly possible that mechanical tasks can be largely eliminated, freeing workers for tasks they find personally more rewarding. It is also possible that they will find jobs more narrowly defined and monitored.

The rapid shift away from jobs in mining, agriculture, and heavy manufacturing has helped create a steady decline in rates of occupational injuries and deaths. Accident rates for manufacturing, for example, are five times higher than those in transactional activities. New jobs, however, present risks that may be difficult to detect. Stress, sometimes induced by job insecurity, may be the most common health problem of high-pressure jobs demanding responsiveness in unusual situations. Rapid changes in production techniques may mean that by the time the health problems of a process are established, the process will be long obsolete.

Strategic Choices.—The challenge of policy designed to influence the way people are used in production recipes is to find a way to encourage supplies of people empowered by their education and experience to assume more attractive positions in the work force, and to encourage employers to build productive systems that create attractive jobs.

A specific challenge is avoiding a potential mismatch between the skills offered by young workers who may have been poorly served by the Nation's educational system, and an economy that increasingly links jobs to education and intellectual skills.

A second goal is to ensure that the costs and benefits of needed business flexibility are equitably shared. Alternatives must be found to flexibility built around lay-offs of people least able to bear the burden.

The following specific programs deserve consideration:

- Encouraging profit-sharing, in which the consequences of poor economic performance of a firm would be shared by employees in an equitable way rather than being, in effect, passed on to those individuals with the least potential for reemployment.
- Establishment of a Learning Research Institute, designed to provide local school systems, universities, and corporate training and retraining programs with an expanded set of tools for increasing the productivity of teaching and learning. The institute would conduct basic and applied research on the use of advanced learning technology, and on the new strategies of pedagogy required to make use of this technology.
- Encouraging, or requiring, universally retainable pensions and health insurance.
- Subsidies for education beyond high school, based on a flexible system of loans and vouchers that could be used to supplement corporate training funds.
- Welfare programs designed to provide incentives for education, training, and reemployment.
- A program designed to ensure that the emergence of flexible production networks often built around comparatively small firms or establishments does not undermine provisions ensuring employee safety, freedom from unnecessary stress, and privacy.

Structural Change in the Eight Major Amenity Networks of the American Economy (Chs. 3, 6, 9, and 12)

The previous discussion focused on a nationwide view of structural change. Many of the most important features of this change, however, cannot be understood without a careful look at the way production networks are being defined to deliver specific amenities. Virtually every production network is either in the midst of a basic change or may be entering one. They share many of the themes already identified: expanded consumer choice and fragmentation of markets, complex production networks, growing involvement in international production, and a profound redefinition of the nature of work. The quality of amenity consumers receive, and the kinds of jobs created to produce this amenity, may change in basic ways. The following section can provide only the most cursory sketch of the complex changes underway in each amenity group.

In some ways the structure of the amenity networks are becoming more similar in the way they are managed, in the quality of the jobs they create, in the way they conduct research, and in the way they are involved in international trade. The unique features of each network, however, merit unique approaches to public policy. Strategies for improving the performance of each network will clearly work best if they are undertaken with a clear grasp of the changes taking place throughout the economy. Similarly, programs designed to improve prospects for growth in the economy as a whole are unlikely to succeed unless they are tested in the way they affect the performance of individual sectors. While the objectives of policy may be read from the following discussion of trends and the potential for change in each major network, no attempt is made to define alternative courses of action.

Food (15 percent of personal and government spending)

The Food amenity can be measured by the quality, variety, and convenience of food products purchased by people in different income groups, and by the extent to which eating habits contribute to good health. The two measures can, of course, give contradictory results.

Better information about the connection between diet and health, changes in taste, and a variety of other factors have reshaped American consumption recipes for Food over the past few years. For example:

- an increased number of working women and more hurried lifestyles have led to growth in restaurant eating, even for breakfast;
- greater concern for health has led to a decline in consumption of red meats and other sources of cholesterol, and to an increase in consumption of fish, poultry, low-fat milk, fruits, and vegetables; and
- there has been an emergence of more varied tastes both in restaurants and stores.

While most Americans enjoy an increasingly varied and healthy diet, poor nutrition continues to be a problem for the elderly, the homeless, poor pregnant women, and other groups.

The network of businesses that bring food to American forks looks increasingly like the networks that bring other retail products to market—similar in the sophistication of their management, in the intensity with which they employ research, in the way manufacturing and business services are integrated into production networks, in the way they are linked to international markets, and in the education and training of the people they employ. Food production remains a major part of the economy, but the productivity of farming has grown so quickly that farming now provides only 3 percent of all jobs. The number of farmers may continue to decline since productivity growth is likely to remain high in most farming activities. There is some concern, however, that inadequate attention has been paid to the problem of increasing efficiency in products other than wheat, corn, and other bulk commodities.

The pizza parable discussed earlier provides some clues about places where productivity growth can be expected. New information technology, improved packaging, and a variety of other technologies can allow a greater variety of fresh products to be available at comparatively low cost. There are some clouds on the horizon. Increases in the scale of firms, from farms to grocery chains, could decrease competition. Foreign firms could continue to capture domestic markets in processed foods and other high-value food products.

The following trends can be identified:

- Consolidation of farm ownership and ownership of food processing and retail operations is likely to continue. By the year 2000, the 14 percent of farms with annual sales of more than $250,000 are likely to be taking 80 to 90 percent of cash receipts. Farms are operated increasingly like businesses in other sectors. The share of managers and professionals in farming has doubled since 1976.
- Net imports of high-value processed foods since 1979 have grown so fast that their value nearly equals the U.S. trade advantage in bulk commodities. Foreign producers are also gaining markets in some food processing technology.
- Grocery stores are getting bigger and offering a greater variety of products. Some stores offer 20,000 products and cover 200,000 square feet. These "superstores" account for 28 percent of all grocery sales. Convenience stores, typically franchise chains, have grown rapidly to fill market needs not met by these super-stores. They are also major financial centers. Supermarkets cash one-third of all non-government checks.
- Restaurants and other food service firms now account for over 5 percent of all U.S. employment. Fast-food, typically in franchises or subsidiaries of large firms, has rapidly gained share. The fast-food format and a variety of technologies like microwaves and deep-fat fryers increased productivity until the mid 1970s, but productivity has not grown significantly since.
- Productivity gains in food manufacturing will continue, but research levels may be inadequate to the challenge. Packaging technology seems particularly critical both to improve quality and to reduce costs—packaging costs more than the contents for a growing number of products ranging from beer to breakfast cereal.

Perhaps most critically, information technologies have the potential to improve the performance and reshape relationships throughout the Food system. Data entered automatically through the scanners that price more than half of all groceries purchased today can improve the productivity of check-out clerks. More importantly, the data entered drives an information system capable of reducing paperwork and improving the efficiency of activities throughout the system. It allows rapid price changes, measurement of consumer response to advertising, closer inventory control, precise dispatch orders for trucking, improved coupon management ($2 billion in coupons were redeemed in 1983) and reduced error rates in billing, ordering, and pricing.

Jobs throughout the Food system are already in flux. Automation is replacing much labor in food preparation and is demanding new sets of skills. Consolidation of wholesale and retail chains, coupled with automated equipment, has eliminated many jobs and has resulted in the substitution of part-time for full-time work. The elimination of skilled jobs in grocery stores (meat-cutting in particular) has reduced employee leverage in bargaining for wages.

In spite of the tradition of independence in American farming, the government is heavily involved in the enterprise. Major Federal programs support prices, regulate international trade, and subsidize research. Farm production commands a significant amount of basic research, a large fraction of which is supported by public funds. The research program has an exceptionally fine record in moving ideas from the laboratory to productive practice.

Government involvement also shapes the geography of Food production. Subsidies for water supplies and price supports have allowed production of commodities like wheat and corn to be profitable in parts of the country that might not otherwise support such production.

Health (11 percent of personal and government spending)

Consumption recipes for good health involve increasingly complex decisions about investments in health promotion (e.g., appropriate exercise), disease prevention (e.g., changing smoking and drinking habits, controlling hypertension), public and private investments in environmental controls and safety devices, and investments in clinical treatment of medical problems. In 1983, approximately $350 billion was paid to health enterprises; $17 billion was spent for self-care medication, fitness equipment, and nutrition aids; and $50 billion for environmental controls.

It seems possible to improve national health status without significant increases in spending given a way that provides a better match between spending and amenity measured in terms of improved health and longevity. Calculations presented in chapter 3 show that average life expectancy in the United States could well reach 80 years without extraordinary breakthroughs in medical technology. This would almost require greater incentives for individuals and households to take responsibility for their own health. Smoking habits, seat belt use, modest attention to diet, prenatal care, the strength of a person's social contacts, and other aspects of lifestyle have a major effect on life expectancy. Improved health would also require strong incentives for research, development, and innovation.

It is also possible to imagine a system choking on regulations and red tape, a system bureaucratized to the point where patient care was compromised in the interest of avoiding litigation or following rigid guidelines. Pressure to reduce health care costs when an aging population needs more health care services could lead to a real decline in health status and increasing inequality among different segments of the population.

It proves difficult to draw a clear line between consumption and production recipes for Health. It is clear that both are changing. A better understanding of the connections between diet, smoking, and other aspects of lifestyle and good health seems to have altered many American habits. The high cost and sophistication of medical technology have made management, research, productivity, paperwork, litigation, finance, and even advertising an important part of a business once dominated by independent private practitioners. These new tasks, coupled with new alternatives for women once willing to work at low wages as nurses, are reshaping the nature of work in Health professions.

New technology, better consumer information, and improved management of health resources have improved the health status of Americans during the past few decades. Life expectancy in the United States has increased 6.5 years since 1950 (the penalty for living longer is that each person spends more time in some state of ill health).

These averages belie great inequalities. Life expectancy in Hawaii is higher than in Sweden or Japan, while life expectancy in Louisiana is lower than in Singapore. Infant mortality rates in Washington, DC are close to those of the poorest developing countries. The differences are due partly to inadequate access to health care, and partly to the fact that differences in lifestyles contribute to differences in health. The comparatively poor U.S. health statistics occur in spite of the high quality of U.S. medicine because of defects in other parts of the American recipe for Health. The health status of the poor is often limited by a variety of social and environmental conditions beyond the reach of traditional health-related spending. A large number of households are not covered by any health insurance program, public or private. This group may grow as the work force turns to greater use of temporary and part-time workers. These people tend to be much sicker by the time they enter the health care system. American mortality statistics are, therefore, not necessarily a good measure of the quality of the U.S. medical facilities. They may instead be a measure of the availability of insurance coverage, inequality in income, racial discrimination, and other social phenomena beyond the reach of medical enterprises.

Technology has obviously made a significant contribution to the quality of American health care. Surgical techniques continue to improve. Biotechnologies promise both new diagnostics and, hopefully, new treatments for a variety of conditions. Engineering advances permit prosthetics, artificial organs, and greater assistance for the visually and hearing handicapped.

Expensive new technologies like Magnetic Resonance Imagery and Computer Assisted Tomography have centralized some activities into "tertiary" hospital centers. Other technologies have permitted treatments once requiring extensive hospitalization to be conducted in smaller clinics or on an "outpatient" basis, and have permitted home treatment to replace some hospital care. Implantable pumps, for example, allow controlled dosage of a variety of drugs outside of hospital settings.

Information equipment may affect health care costs, health care quality, and the structure of Health businesses as profoundly as any of the technologies just listed. More sophisticated management systems, growing complexity of procedures, and an avalanche of paperwork connected with cost-containment and (increasingly) legal issues have made information management a major part of the health care business. Computer-based record management has improved efficiency and reduced costs in everything from patient billing to inventory control. It is now possible to store high-resolution photographs of specimens and other records electronically. Information equipment permits small home care firms to manage complex paperwork. New technology can permit rapid communication between specialists in different parts of a city, or indeed different parts of the country. It can permit telemetry to monitor patients being treated at home.

The challenge of better integration of health treatment can be seen in the baffling statistics on use of different therapeutic techniques. The probability that a women will have a hysterectomy, for example, is 20 percent in some markets and 70 percent in others. At least one (possibly both) of these regional practices must be wrong. Information equipment should be able to permit more precise sharing and analysis of procedures. In some cases, information equipment can even provide a "second opinion" for a physician otherwise forced to rely on his or her own memory about techniques.

The effects of these and other changes have already transformed the structure of "production" in health enterprises. Once dominated by general practitioners who would occasionally refer a patient to a hospital, the business of medicine now integrates individual practitioners, group practices, and tightly managed hospital corporations, as well as a growing array of satellite institutions: testing laboratories, out-patient clinics, hospices, nursing homes, home-care specialists, and even "doc in a box" emergency care facilities in shopping centers. The number of people receiving medical care from a health maintenance organization (HMO), as opposed to a privately practicing physician, nearly doubled from 1981 to 1985. Using modern management techniques, hospitals and other health organizations are beginning to behave like other service organizations. Enormous investments in environmental protection have created wholly new business opportunities. Cleaning hazardous waste sites alone promises to generate a significant amount of future business.

The changes just discussed are also transforming the nature of health as a profession. Physicians are frequently hired on fixed salaries much as any other technical professional. A shortage of nurses is developing as women realize that other occupations result in greater returns for equivalent levels of experience and education, and typically offer less erratic hours.

The cost of new technology, coupled with rapid growth of the elderly population and expanded public insurance programs, have also led to explosive growth in health care costs and have spawned a number of regulatory remedies to control costs. While it may well be that Americans would freely choose to spend an increasing share of their incomes on Health, the question of whether spending levels are or are not appropriate cannot be resolved by a simple appeal to market forces. The task of designing a financing system that provides incentives to maximize the quality of health outcomes while minimizing costs has proved to be vexing for both public and private insurance programs.

By the early 1980s, there was general agreement that the incentive and regulatory systems in the health industry needed revision. Both private and public insurers moved away from "fee for service" reimbursement. The challenge has been to find a substitute that does not collapse under ever more invasive regulation. Government and private insurance regulations have attempted to force greater attention to the costs and benefits of different treatments. As a result there has been some reduction in patient use of hospitals and physicians. Hospitalization rates for prepaid plans, where hospitals have a strong incentive to minimize costs, are 10 to 40 percent lower than those for people with insurance that pay fees for services. Physician visits per person have fallen since 1976.

Housing (20 percent of personal and government spending)

Owning a detached home remains a firm part of nearly every American's vision of a good life. Decent housing is largely a matter of taste, but it surely includes security, a pleasant landscape, low maintenance, and low operating costs. It also means a pleasant home with access to jobs (frequently jobs for several members of the household), shopping, schools, and day care facilities.

Changes in taste and demographics also redefine definitions of housing quality. The rapid growth of the elderly population, for example, creates new housing needs. Fully 40 percent of Americans aged 65 to 74 have some kind of disability that limits their activity, and 63 percent of those over 75 have some disability. Shrinking leisure time has made the amenities of a comfortable home substitute for other forms of recreational spending. Homes have also become centers for home health care, and even places of part-time work.

Housing is, of course, an investment in addition to an amenity. Home ownership differentiates those with assets from those that lack them in contemporary America. The net worth of households owning homes is nine times higher than the net worth of renters and home equity represents two-thirds of the net worth of home owners. The high mobility of Americans reinforces the tendency to consider a home a temporary investment, with purchasers paying as much attention to the hypothetical desires of the next buyer as to their own.

On average, the quality of American housing is improving. The average home has more rooms per person, and is more likely to have air-conditioning, a full garage, and a well-equipped kitchen, than ever before. On the other hand, home ownership has moved beyond the means of many young Americans, particularly those moving to areas where employment is expanding rapidly. The fraction of median household income needed to purchase a new home is more than 50 percent above what it was in 1968. Housing costs are also an increasing burden for poor families, particularly homes with a single wage earner. The cost of buying the average new house would require 75 percent of the average income of single women. One result of these trends has been an increase in renting. The extreme symptom is growing homelessness.

Many households have found affordable housing only at considerable distances from their jobs—a major problem for households with two earners. In effect, housing costs are traded against the cost of time spent commuting. Only half of the people in the San Francisco area now work and live in the same town. Since men commute 35 percent more miles and spend 15 percent more time commuting than women, it appears that women may be taking jobs closer to home, possibly sacrificing income in order to combine lives as a homemaker and paid employee.

The high cost of housing results from several factors:

- Land costs have soared, particularly in rapidly growing urban areas. Growth constraints have exaggerated the problem in many areas.
- Changes in regulations have forced purchasers of home mortgages into competition with wider financial markets. Financing expenses remain a dominant housing cost.
- Productivity has fallen in construction.
- Rising energy prices have increased the price of home operations.

The costs associated with land prices are obviously not touched by changes in the production recipe just described. They require changes in the efficiency of transportation, changes in tax laws that may encourage speculation, and policies that may affect the location of jobs, retail facilities, recreational facilities, and other destinations.

The recipe by which houses are produced has not changed significantly in some time. In spite of forecasts about factory-built housing dating to the early 1930s, little has actually happened. Radical swings in demand for new housing, and a history of fragmentation in home construction businesses, has kept research and capital investment in this industry far below that of most manufacturing firms. There are reasons to believe, however, that significant change is not only possible but necessary.

The U.S. housing industry could follow the trends of the industry in Sweden and Japan, moving construction away from highly fragmented small firms with few investments in capital equipment or trained employees, and toward production networks that more closely resemble other manufacturing operations. The result would be a profound change in the nature of the institutions supplying Housing in the United States, as well as a change in the quality of the product:

- The house itself could be designed on the basis of more systematic research. At present, most innovations come from component suppliers, with little research directed at the integrated performance of the structure itself. There is compelling evidence that simple, inexpensive changes in home design make new homes not only more comfortable but less expensive to operate.

- Factory construction could lead to both greater reliability and energy efficiency. Houses could be "brand name" products with multi-year guarantees of reliability.
- Productivity of home manufacturing could benefit from greater capital investment in production facilities and the use of advanced assembly techniques. The home building industry invests little in improving production technology.
- Homes could be assembled by firms specializing in site preparation and rapid site assembly of factory components. These firms could either be independent or franchises of larger firms (as they are in Sweden).
- Homes could be marketed from showrooms, where prospective clients can design floor plans and explore alternative exterior and interior finishings on computer screens. The Japanese claim to be able to convert designs into finished houses in 3 weeks.

Changes of the sort just described could radically change the nature of construction work. The construction industry has always achieved a high degree of flexibility by using temporary work teams. It has an extraordinary ability to assemble many disciplines quickly. Changes in production recipe could make construction work more closely resemble jobs in other manufacturing industries. (Of course, it is also likely that manufacturing enterprises will change in ways that may make them more closely resemble construction in the way work teams are assembled on short notice.)

If the construction industry began to resemble the organizational structure of manufacturing, a large number of design, research, and customer support jobs would be created. Sales operations would combine design, finance, and marketing. Production work would involve programming equipment to produce unique products, maintaining sophisticated equipment, and learning to operate new tools.

The changes in construction networks could, however, also be used to replace skilled construction jobs with low-paid, low-skilled employees in production facilities. Many "factory" construction facilities in the United States use temporary labor.

The U.S. home building industry has largely been shielded from foreign competition but the situation has changed rapidly. Foreign appliances, fittings, and other components are entering U.S. markets rapidly. There is a real risk that without some significant change in the productivity of U.S. construction techniques, U.S. firms could become little more than assemblers of foreign products using foreign-made tools.

Without some change in housing technology or policy, a growing number of Americans may find themselves faced with painful choices between cramped quarters and long commutes. It is possible that productivity would continue to decline, and U.S. home owners may be burdened with continuing increases in home prices, and with inefficient structures in which operating costs could rise sharply if energy prices increase.

Since residences consume nearly 30 percent of all electricity generated by U.S. utilities, and are largely responsible for the peak demands that motivate new plant construction, there is a critical need to communicate accurate costs to residential customers. Residences also consume approximately 20 percent of U.S. oil and gas. It should be possible to cut energy consumption of new homes in half with improved windows, lighting, appliances, better heating and air-conditioning controls, and advanced materials. Moreover, communications technologies are being tested that can help households adjust electricity use to minimize cost both for themselves and the utilities. This will require pricing electricity not as a commodity but as a product whose value depends on the season and the time of day.

Transportation (11 percent of personal and government spending)

The amenity of Transportation is measurable by the extent to which people can go where they want, when they want. This has become almost synonymous with travel by automobile; 86 percent of all work trips in cars were made alone in 1983, and the driver was alone in a car for 60 percent of all vehicle miles traveled. In spite of massive public investments, travel on public transit continues to decline. The comparatively low densities of most U.S. living and working areas makes transit a poor alternative for all but the most densely populated urban centers, such as New York, Chicago, Boston, or Philadelphia. Mass transit is often used only as a last resort. One-third of mass transit passengers live in households that do not own cars. The central challenge of personal transport in the United States remains one of preserving the amenity inherent in a personal vehicle while providing needed mobility for those unable to drive.

Complex networks of production have altered demand for business transportation services (typically demanding more reliable and timely deliveries), and have changed the geography of production and the location of jobs. Demographic changes and changes in housing costs have shifted the location of housing. The result is new patterns of demand for both personal and business transportation.

In 1980, 60 percent of the 31 million commuters in the Nation's 25 largest urban areas lived in suburban areas and traveled to jobs outside the central business district. There is now one car for every licensed driver. Public transport is increasingly dominated by air travel, which has appeared as a substitute for long bus and train trips.

There has been little net improvement in the real efficiency of auto travel. The real costs of driving a mile have not changed significantly in 15 years. Imports of inexpensive and durable cars increased competition for domestic markets and placed new emphasis on quality and fuel economy. These improvements have largely offset the higher cost of fuel. On the other hand, travel times to work and shopping remain comparatively unchanged because of a combination of congestion and decentralization. Little can or will change without both private efforts to improve personal vehicles and a public effort to provide improved highways. The recipe for Transportation plainly involves a coordination of public and private investment.

Transportation provides an enormous variety of jobs, ranging from high-skill/high-wage positions for airline pilots to minimum wage jobs in gasoline stations. Since personal transportation is by private automobile, Transportation provides as many jobs in manufacturing as it does for paid vehicle operators.

It should be possible to make the Nation's Transportation system faster, more flexible, less costly, and safer by increasing the variety and capabilities of personal vehicles. High-performance, two-passenger vehicles could be given privileged commuter lanes and parking. Low-speed vehicles with minimal licensing requirements could provide mobility for the elderly or young teenagers in communities. Improvements are also possible in the coordination of traffic signals, and better information on congestion and road conditions can be transmitted to individual vehicles—again, a combination of private and public equipment.

Improved communication systems may permit more people to work at home, but it appears unlikely that this will significantly reduce transport needs. On the contrary, communications technology may increase travel, by making more people aware of opportunities for business, shopping, and recreation. Cellular telephones can even make cars double as offices.

The near doubling of fuel economy of automobiles played a major role in reducing U.S. and world petroleum imports. It is possible to achieve another doubling or even tripling in fuel economy without significant sacrifices in vehicle performance. A coordinated movement to a fuel other than gasoline would also ease pressure on the system. This, too, is likely to require public as well as private investment if such a transition is to occur before a crisis strikes.

Without some imagination to break the current stagnation in the performance of the personal transportation system, it is possible to imagine a system that not only fails to improve but that offers declining levels of amenity. The system could become increasingly congested and poorly matched to the diverse needs of a complex society. It could also fail to serve the needs of production systems dependent on fast, reliable, flexible transport systems. Without adequate investment, the existing Transportation infrastructure could deteriorate, and congestion along existing highways could increase. A system heavily dependent on oil could be very vulnerable to the availability and price of foreign oil.

Clothing and Personal Care (7 percent of personal and government spending)

Americans are clearly impressed by the symbolism of clothing, and clothing purchases rise sharply with income. Americans consume twice as many square yards of cloth per person as the average French or German consumer.

The technology of production in textiles and apparel is going through revolutionary changes. Computer-driven shuttleless looms and cutting machines now dominate the market. Apparel assembly, which the industrial revolution seems to have bypassed, may soon be automated using robotic sewing equipment now entering the market.

Perhaps more importantly, the network connecting producers together appears to be on the brink of a major change. The change is forced both by new technology and the pressure of imported products that have devastated markets for domestic producers in a growing number of products. The industry is moving quickly to integrate operations from fiber production to retail outlets. The goal is to make a radical reduction in the 65 weeks now required to move fiber to a retail store in the form of finished apparel. This is done through adoption of standardization, responsive transportation systems, and production equipment that allows high productivity in comparatively small batch production. These responsive systems allow retail outlets to carry more products in more sizes without increasing inventories. The cost of producing products tailored to a person's unique measurements may soon be little more than the cost of mass-produced garments. If this occurs, the industry will have come full circle from tailoring to commodities and back to tailoring in a hundred years. Ironically, the productivity of individual steps in this network (e.g., trucking or weaving) may decrease while the productivity of the system taken as a whole may increase.

Given the intense nature of foreign competition, it seems apparent that the network delivering apparel to U.S. consumers will either have to undergo major improvements in productivity or become little more than a vendor for foreign products. On the other hand, it is entirely possible that a flexible and responsive domestic system can provide customers with fashions and service impossible to provide from foreign suppliers.

Whether reshaped by trade or by new technology and management systems, employment in the collection of enterprises just described will change. The trend is already evident. Between 1977 and the end of 1987, employment in the apparel industry fell 16 percent and textile employment fell 18 percent. Heavy investment in modern production equipment has eliminated many jobs in fiber production and textiles. Automation will also reduce jobs in apparel assembly. The jobs eliminated will largely be those held by people with comparatively low skills. Many of them are minorities with few resources for other jobs. The jobs created will require skill in managing orders, maintaining and programming sophisticated equipment, and other functions likely to require a significant amount of specialized training. Some effort will be needed to provide people now employed by the industry with the new skills needed.

Job loss in textile and apparel production is partly offset by rapid growth in apparel retailing. Retail apparel and accessory stores provide jobs for nearly 1 million people, and over 2 million people are employed by department stores.

In spite of the importance of this sector of the economy, the U.S. Government spends few resources on research and development work for textile or apparel technology.

Education (7 percent of personal and government spending)

Education is both an end and a means to an end. It provides tools critical for finding rewarding employment in a complex economy. Education also proves to be strongly correlated with health, and with an ability to recover from such personal disasters as illness, divorce, or a job loss. It opens doors to cultural opportunities that are otherwise inaccessible.

Education is also one of the Nation's largest enterprises. Between $300 and $500 billion are spent on Education each year (the range results from an inability to count corporate investments in Education). The total investment in learning exceeds the $240 billion annual private investment in buildings and structures. About one American in three is enrolled in some kind of educational program during the year.

The Nation's educational system may be on the brink of a major change. This results both from a fundamental change in the demand for educational services and from the fact that new technology makes it possible to consider real improvements in the productivity of both teaching and learning. Taken together, these forces could change what is taught, when it is taught, where it is taught, and the nature of teaching as a profession. There are some stark alternatives:

- The system could change in a way that makes learning more productive and fun while allowing teachers more time to spend with individuals as coaches or tutors. It could put more power in the hands of the learner, tailor instruction to each person's level of understanding and learning speed and technique, and make it easier for an individual to learn when instruction is most needed.
- The system could create rigid centralization of course design, mechanical and impersonal instruction, national regulation, and a contraction of choice for both students and instructors. Adult training programs could widen the gap between those with good educational skills and those lacking them.

The difference between the two depends heavily on public choice.

Demand for Education has changed both in qualitative and quantitative terms. Demand for formal educational services (K-12 and college education) declined with the graduation of the baby boom generation, while demand for adult training has increased. Not only do the emerging jobs require a higher level of educational skills, but jobs are changing in ways that require a continuous renewal of skills. The kinds of basic skills required of entry-level employees are reshaped by these new demands. Skills in working with people in groups, in self-education, in coping with ambiguity, and in coping with too much or too little information become requirements as important as any specialized training.

The real costs of employee training are almost impossible to measure. Formal training can be tracked, but the costs of informal training and of problems created by inadequate training (e.g., Three Mile Island) are more ambiguous. They are obviously very large. It appears, however, that people most likely to benefit from formal and informal on-the-job training are those who come to the position with a good basic education. If anything, retraining appears to be widening, not reducing, the gap separating highly skilled from unskilled employees.

The basic characteristics of America's educational system have not changed significantly in a century, and each student continues to have unique learning styles and interests. The existing educational system appears to be highly personal and differentiated. However, the isolation of individual instructors may have the opposite effect. Studies indicate that a typical student in primary or secondary school (grades K-12) receives less than 1 minute per day of individual attention. Teachers throughout the country teach nearly the same course from similar texts, and spend large fractions of their time repeating standard lectures or performing routine administrative functions. Apart from buildings, desks, and blackboards, virtually no capital equipment is used in this, the Nation's largest information enterprise. Television has not proved to be a major asset.

Over the next two decades, capital equipment could improve the productivity of Education at all levels given adequate research and capital investment. New information technologies allow active response to students not possible with television—a critical distinction. Existing "computer-based instruction" systems are often disappointing, primarily because of the limitations of existing software. But there is reason for considerable optimism.

Artificial intelligence techniques could help diagnose defects in what a student understands, while less exotic software could help with needed drill and practice. Simulations that use images, sounds, and text can lend realism, and can remove the barriers of abstraction that so often impose themselves between formal education and practical mastery of a subject. Indeed, since the working life of many graduates will increasingly be spent viewing reality through computer screens—whether they are operating nuclear powerplants or analyzing a commercial insurance policy—the distinction between simulation and reality can be extremely small. Communication systems could forge links between teachers working in similar areas, permitting specialization not possible in comparatively small schools. They could also allow students to work more easily with each other, and could help tie homework to school work.

Significant changes are likely in the nature of teaching as a profession even if technology is not widely introduced. There are new demands for instructional quality and efficiency. At the same time, women who might once have entered teaching because they had no other professional opportunities are now being drawn into a variety of other occupations. Introduction of more capital equipment and expansion of teaching beyond traditional school settings will lead to much greater differentiation in an occupation now called "teachers." Tasks involving software development, equipment maintenance, holding tutorials, working with students around the country in a highly specialized area, identifying learning pathology, and a range of other areas will lead to jobs for a variety of specialists, and doubtlessly a variety of pay scales.

Firms ranging from insurance underwriters to producers of metal parts have found that the potential efficiency gains from new information technology cannot be captured without a profound change in management strategies. Education will be no different. Management reforms are, however, notoriously difficult in Education because of the sector's fragmented nature. Hundreds of State and local governments manage K-12 instruction. This has a healthy effect by allowing teachers considerable power in resisting grand schemes unlikely to further instruction. In some cases, however, the extreme fragmentation can frustrate progress. Corporations and the Armed Forces have moved most rapidly to exploit the advantages of new instructional technology. This is due in part to a different style of management, and in part to the fact that since these organizations pay salaries of both students and teachers, they are as interested in the productivity of a student's time as the productivity of the teacher's time.

As in many other sectors examined here, making full use of the potential of emerging technology requires a major investment in research. At present there is no national center for focusing research on education equivalent to the National Institutes of Health or the Agricultural Research Center. By far the bulk of research on educational technology supported by the Federal Government is undertaken by the Department of Defense. While a private information company typically spends several percent of gross revenue on research, virtually nothing is allocated for research directed at the real problems of teaching and learning. If the fraction of gross expenditures invested in research were the same for Education as for the average privately owned business in the United States, about $9 billion a year would be spent for Education research. This is 60 to 90 times more than the present allocation.

Personal Business and Communication (6 percent of personal and government spending)

Astonishingly little is known about the volume or the function of information entering or leaving U.S. homes. By far the greatest volume of information is broadcast to homes through television, radio, and direct mail. Large amounts of information enter through selective purchases or rentals of video tapes, magazines, books, newspapers, and cable television. Two-way "point-to-point" communication, involving telephone conversations and correspondence, is responsible for a comparatively small fraction of the volume of information, though this activity traditionally receives much more attention.

Most of this information is used for entertainment. The economics of information are curious, since much of it is subsidized by advertisers. Advertising pays for nearly all broadcast costs, and 50 to 75 percent of the cost of newspapers and magazines. The costs paid by individual consumers come entirely in what they pay for receivers, and in the time spent watching advertising messages.

Apart from entertainment, information is used largely for personal business—primarily for retail purchasing, but also for financial transactions and bill paying. Keeping in touch with friends and even gossiping represent other critical markets.

Direct marketing has enjoyed an expanded business, using television and direct mail to communicate from businesses to homes, as well as 800-number telephone systems and credit cards to communicate from homes to businesses. In the future, some of this electronic shopping will certainly become part of computer-based systems. One key barrier to computer-based systems is the lack of serendipity: when people enter files looking for something in particular, spontaneous response to products is not possible. Cable television has introduced a novel way to bypass this problem, by holding what amounts to a continuous sale where proprietors take telephone orders for products shown.

How should amenity be measured in this case? By analogy to Transportation, improvements in information resources depend on a person's ability to get the information he wants when he wants it (leaving a little room for serendipity). It seems that this system is moving rapidly toward one with greater consumer choice, more control over the information that enters the home, and more direct payments for services actually used. VCRs, cable television, and the explosion of specialized magazines have all allowed special tastes to flourish where broadcast television and general interest magazines once dominated markets. Similarly, the once undifferentiated telephone has been replaced by a variety of specialized products, ranging from $6 disposable phones to ports of entry into sophisticated data management services. Advanced communications to homes can also mean more control over electricity bills, better home health care services, and greater opportunities for education, while cellular communications can extend such freedoms to private vehicles. Many more services are likely to be available as the struggle over regulation of telephone services is resolved.

The deregulation of banking, coupled with sharp increases in the incomes of many households, has generated a boom in individualized financial services. A growing fraction of all households use tax accountants and financial advisors to provide specialized services. Few now buy "whole life" policies that combine savings with insurance.

While deregulation has spawned an explosion of competition, it has not had the effect of creating much real diversity in most markets. AT&T, for example, retains 90 percent of the long-distance market. Local telephone companies maintain regulated monopoly control over local telephone services, and are gradually being allowed to compete with other firms for lucrative advanced communications services. There is a possibility that these firms could expand on their regulated business to become regional monopolists in a variety of unregulated areas.

The businesses in this group provide jobs dominated by clerical and information management occupations. The complex pattern of change possible in these occupations has already been discussed. In some cases, modern communication equipment has fragmented jobs into narrow functions that can be carefully monitored by electronic means. This has been true for telephone operators or clerks working on routine insurance accounts. In others, clerical tasks have been upgraded and combined with quasi-managerial tasks. This is particularly the case when products cannot be handled using mass production techniques (e.g., commercial insurance). Between 1983 and 1986, employment growth in clerical and other administrative support personnel slowed in finance, insurance, and real estate businesses, while jobs for people classified as managers, professionals, and sales workers increased rapidly. There is much uncertainty about the future of employment in these occupations, and much room for choice.

Recreation and Leisure (9 percent of personal and government spending)

Of all the sectors examined in this analysis, the amenity of Recreation and Leisure is most difficult to measure objectively or even define precisely. How can the recreational value of dining be separated from biological necessity? How much of a purchase of a home or a car can be considered recreational? Obviously, both time and money are critical when considering this amenity.

Free time available to Americans has been shrinking for at least a decade and, as a result, spending for Recreation and Leisure has typically become more intense (more spending per unit of time but less time). Moreover, Americans earn far fewer vacation days than their counterparts in Europe. U.S. manufacturing employees averaged 29 days of paid vacation and holidays in 1982, while the West Germans took 41 days and the French 35.

Outdoor recreation and travel command a firm share of U.S. leisure time in spite of advances in home electronics. In fact, home electronics may have expanded interest in travel and in a greater variety of away-from-home activities. Time constraints remain a bigger problem than money for many families. Vacations tend to be short and intense, and many households now look for short trips close to home in lieu of the traditional "two weeks at the beach" vacation. There is little sign that national tastes in recreation are becoming more homogeneous. Business is booming for everything from theme parks to National Barbecue cooking contests to Mississippi Catfish Festivals. Hotels and motels cater to specific client groups, such as older couples or families with children.

In the future, technical capabilities of home electronics should continue to expand quickly. Investments in home capital equipment now include video equipment (where high-definition TV can greatly improve picture and sound quality) and sophisticated audio equipment (digital disks and tapes offer remarkable improvements). New information technologies also promise to expand opportunities for travel. Airlines were among the first to use sophisticated national reservation systems. Travel agencies (an industry that has been growing rapidly in recent years) offer growing variety of information services. Reservation services can be provided for hotels and motels, automobile rentals, sports and theater events, and a variety of other activities. Some agencies are introducing expert systems to help match unique interests to travel reservations. In the near future, reservation systems will permit a video tour of prospective destinations, hotels, and even individual rooms. Prototypes are already in place.

It should be possible to enrich opportunities for using leisure time through the use of advanced technologies, which can bring a greater variety of entertainment, education, and shopping services to individual households and improve access to recreation and entertainment facilities away from home. On the other hand, recreation and entertainment opportunities could be curtailed for all but the affluent, given a decline in advertiser-supported TV and newspapers or a decline in public support for parks, town centers (as opposed to privately managed shopping malls), and cultural facilities and activities.

Many outdoor recreation activities involve an integration of publicly supported infrastructures, such as parks, beaches, civic centers, and sports stadiums, and private investment, such as hotels, travel agencies, and theme parks. Many businesses depend on public investment in these infrastructures, and on public efforts to maintain the quality of the environment in parks and other recreation areas. There may also be a role for public information services such as the city of Baltimore, Maryland's INFOTOUCH.

Not counting jobs in transportation services or jobs in restaurants, the Recreation and Leisure industries are responsible for 8 percent of American jobs. Many, like those for hotel employees or employees in theme parks, are comparatively low paid and are in occupations where productivity increases are difficult to envision. In fact, hotels appear to be becoming more, and not less, labor-intensive. On the other hand, the production and distribution of consumer electronics and the software used on these systems can create many rewarding jobs. American production of many consumer electronics products has all but disappeared in the face of foreign production. Foreign producers have used their command of manufacturing the current generation of consumer electronics products to fund the development of a continuing series of innovations. U.S. firms will need to move aggressively to recapture these promising new markets.

Pulling the Pieces Together (Ch. 13)

The kinds of change discussed so far will have far-reaching effects on the future of the U.S. economy. Unfortunately, none of these effects can be confidently forecast because virtually none depends on immutable natural forces. On the contrary, the Nation's economic future depends as never before on choices made by households, producers, workers, and the government. These choices will, of course, also be shaped by the regulations and incentives the government oversees, and by the skill with which the government manages international affairs.

Forecasts where so much depends on choice are absurd. What can be done, however, is to sketch out self-consistent descriptions of the different kinds of economic structure that *could* emerge in the United States during the next two decades. The implications of public and private choices become clearer when displayed in this way.

Four scenarios are used in this report to explore the implications of alternative futures for the U.S. economy. These postulate:

1. continuation of present trends,
2. a recovery of the manufacturing sector,
3. a stagnating economy, and
4. a transformed economy making optimum use of new technology.

The results range from cases where GNP grows slowly (1.5 percent per year) and unemployment reaches 23 percent (measured in conventional terms) to one where GNP grows rapidly (3 percent per year) with possible labor shortages. While there seems to be no question that the second case is preferred, this quick judgment should perhaps be suspended while some of the fine print is examined. A case could be made that GNP growth does not necessarily provide a good guide to progress. Indeed, the scenarios reveal that the choices made by consumers can greatly affect the level of amenity they achieve, particularly in areas such as Health, mobility, and Housing, even if their incomes do not rise. Improved amenity achieved with a working week of 35 hours (which would drastically reduce unemployment) may look better than 3 percent GNP growth that fails to raise living standards equitably. With careful management, however, it should be possible to have both rapid growth *and* improved amenity.

Changes in personal and government consumption recipes, and in income distribution, have a surprisingly small impact on the economy in terms of the share of value-added or jobs in manufacturing or other sectors—although individual enterprises would obviously be affected much more strongly.

The different scenarios also reveal interesting information about the future of natural resources and energy consumption. Changes in household and government spending recipes can have a significant impact on national use of energy. The combination of greater attention to energy efficiency by consumers, and production recipes that demand less energy and material inputs, can lead to a significant decline in national use of resources. Optimal use of new technology could result in a 40 to 60 percent *decline* in use of natural resources, even when there is rapid (3 percent) economic growth.

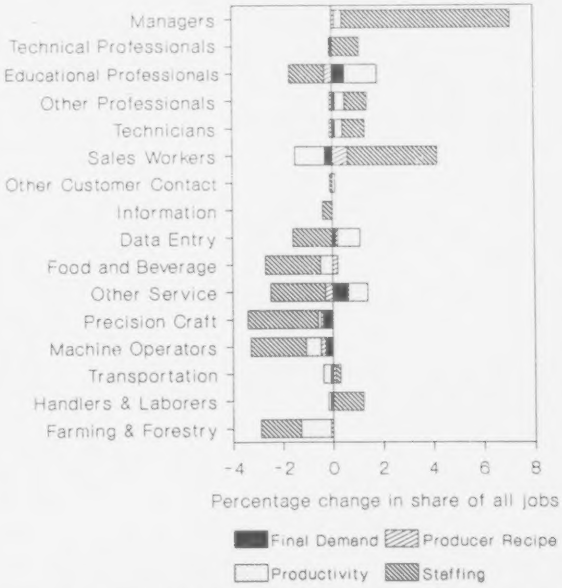
Since air and water pollution, and the generation of hazardous waste, scale roughly with demand for energy and material resources, these differences obviously translate into large differences in future environmental quality. The scenarios thus demonstrate that it is possible to have vigorous economic growth while reducing demands on the natural environment. Indeed, most innovative production schemes result in a decline in environmental releases simply because most new technologies are intrinsically more efficient.

The impact of trade depends both on whether trade volume continues to grow as a fraction of GNP (in constant dollars) and on the nature of U.S. exports and imports. High levels of trade can lead to a net increase in employment since in many cases the number of jobs generated per dollar of exports exceeds the number of jobs lost per dollar of imports. Employment in manufacturing and agriculture is particularly vulnerable to different patterns of trade.

Changes in production recipes, and assumptions about productivity in each industry, have the largest effect on the *industries* likely to produce jobs in the future. Changes in the type of occupations required in individual industries, however, have an even more profound effect on the number of jobs created in each *occupation* (see figure 1-24).

All the scenarios share some characteristics. Employment in manufacturing during the next two dec-

Figure 1-24.-Why Occupation Shares May Change



How To Read This Figure: The "Trend" scenario examined in chapter 13 estimates that between 1984 and the year 2005, the share of all jobs held by people classified as "other professionals" will increase 1.3 percentage points. These occupations would have increased their share 0.9 percentage points if only staffing patterns *within* businesses had changed (the scenario assumes sales workers in proportion to other workers in most businesses). All else being equal, the comparatively slow rate of growth expected in the productivity assumed for businesses using large numbers of "other professionals" would result in a 0.4 percentage point increase in the share of these occupations.

SOURCE: Office of Technology Assessment (see table 13-8 of ch. 13).

ades will not decline as rapidly as it has in the past 20 years. Manufacturing employment seems likely to fall from about 20 percent of all jobs to between 16 and 18 percent in 2005. Measured as a (constant dollar) percentage of GNP, manufacturing may fall by only 1 to 2 percentage points, with declines occurring primarily in manufacturing sectors that now pay comparatively high wages. Also breaking a trend, jobs in transactional activities (such as banking, insurance, law, and business services) seem unlikely to grow substantially as a fraction of all jobs. This results in part from the fact that productivity may grow sharply in "paper pushing" activities, thereby reducing the work force required.

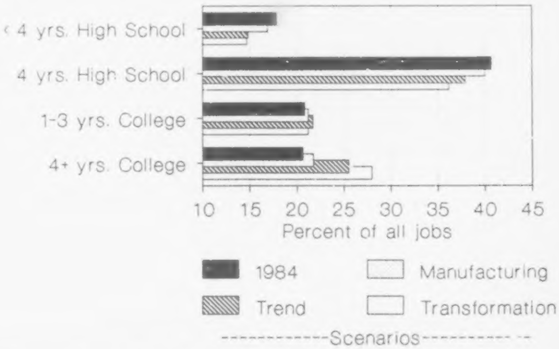
The characteristics of employment possible in the future differ most strikingly when measured by the type of job created. An economy that manages to build growth primarily around a revitalization of traditional manufacturing produces many more craft workers, precision production operators, and other "hands-on" manufacturing occupations. An economy moving sharply to new production networks generates many fewer jobs of this type, twice as many jobs for technical professionals (compared with an economy following 1984 staffing patterns), nearly 25 percent more managers and management support personnel, and 30 to 40 percent more sales workers. There would also be a 30 percent decline in jobs involving routine data entry and manipulation, and fewer jobs for the most low-paid occupations (food preparation, low-paid service workers, laborers, and farm labor).

The transformation scenarios have the effect of reducing employment in categories that traditionally pay low wages (the fraction of all workers now in occupations paying less than two-thirds of median wages could fall by 40 percent) while increasing employment in traditionally well-paid jobs (the fraction of all workers in occupations now paying more than 33 percent above the median wage could grow 50 to 60 percent). Of course, nearly all these occupations would be redefined if such a transformation took place. Many managers are likely to have more routine jobs than today's managers. Sales workers in the future could have more demanding jobs if they were more tightly integrated into inventory control and production networks, and given greater control over the design and tailoring of products sold.

The statistics say little about the quality of the working environment, an employee's control over working life, or satisfaction with what is accomplished. It does appear, however, that a restructured economy could generate large numbers of interesting and rewarding jobs, ranging from interesting "face-to-face" sales positions, to technicians installing and repairing a continuing series of new hardware and software, to managers wrestling to build new teams for specialized projects. These jobs will be in occupations that currently require a high level of education. The educational attainment level experiencing the fastest increase in its share of jobs, both currently and under the Transformation and Trend scenarios, is the highest—four or more years of college (see figure 1-25).

On the other hand, it is also possible to produce jobs that allow individual employees few initiatives and monitor performance with Orwellean precision using advanced communication networks. The combination of technology and large numbers of entry-level people with poor basic education could force (or tempt) employers to produce large numbers of jobs requiring minimal training for people considered interchangeable and disposable.

Figure 1-25.-Educational Requirements of Future Scenarios



How To Read This Figure: College graduates held about 21% of all jobs in 1984 but would hold nearly 28% of all jobs under the assumptions of the Transformation scenarios.

SOURCE: Office of Technology Assessment (see figure 13-2 of ch. 13).

A Concluding Note

The calculations just presented, coupled with the more qualitative descriptions that preceded them, describe starkly contrasting futures for the U.S. economy. They paint very different pictures of the future of critical amenities, the potential for growth in major types of businesses, the relative position of the United States in the world economy, and the nature and rewards of jobs available. The range of possibilities is shown not as forecasts but as possibilities—possibilities that illustrate the power of and the need for careful choice in the construction of public policy.

Part I

The Networks of Consumption

While many of the most basic aspects of economic structure are in flux, human needs and desires provide a fixed point of reference. Whatever happens in the future, the output of the U.S. economy must ultimately be measured by the extent to which it allows Americans to achieve "amenity": to be in good health, to have a varied and healthy diet, to be well clothed, to live in attractive housing, to receive a useful and interesting education, to expand options for personal communication, to travel, and to enjoy leisure time. Together with national defense and other functions necessarily provided by collective rather than individual purchasing, these amenities represent the real output of an economic system. The net productivity of the U.S. economy must be measured by the efficiency with which human time and talent are applied to their achievement.

The next two chapters define methods for measuring growth in amenity, and describe the "consumption recipes" used by Americans to achieve these amenities. These "consumption recipes" combine household purchases of goods and services, investment of unpaid time by household members, and public spending. The chapters provide a basis for describing possible changes in purchasing which, in turn, affect the structure of the producing sectors of U.S. economy, and ultimately the jobs that the economy creates.

It is not possible to develop a rigid definition of quality in any of the major classes of amenity. Concepts of quality are often readily understood—freedom of choice, good health, or happiness—but may be impossible to quantify. Some purchases are based on need, and some on choice. Some are spontaneous while others are induced by advertising. Many are shaped (or misshaped) by regulation, instinct, ignorance, or hasty decisions. Even if it were possible to develop a perfect way to measure amenity for an individual, it would be impossible to develop a perfect formula describing amenity for society as a whole.[1] Once incomes are adequate to provide for basic necessities, the extent to which spending buys satisfaction depends heavily on expectations. The quality of amenities available to a person considered wealthy at the turn of the century is below the expectations of even the poorest family today. On the other hand, the well-educated baby boom generation may have expectations that will be difficult for the economy to meet.[2]

The problem of defining and measuring amenity can, of course, be avoided if growth in national income can be used as a proxy for economic progress. Given this assumption, productivity can be measured by the efficiency with which labor and other inputs are converted into measurable quantities like CAT scanners, and not by the facility with which resources achieve longer lives or greater freedom in personal transport. Yet while such an approach solves many analytical problems, it is insufficient for the purposes of the analysis that follows for two critical reasons:

- Measures of amenity that are independent of spending levels are needed to consider public policy choices affecting the way consumers combine goods and services. There are obviously many cases where income measures of economic welfare are not adequate. Defects in public regulation or inappropriate public spending can be responsible for inefficiencies in the way consumers convert money to amenity. The quality of life in a community can decline while incomes increase if environmental quality deteriorates or social unrest undermines security. There may actually be a negative correlation between spending for health care and life expectancy, or between spending for burglar alarms and security. Policies designed to facilitate private choice can only be assessed given a clear understanding of the performance of networks that connect spending with amenity measured in human terms.

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[1] Kenneth Arrow argues that even if a function could be written to describe the way each individual would rank the value of different patterns of expenditure, it would be impossible to combine these functions to develop a method for ranking expenditure patterns for the group taken as a whole. K. Arrow, *Social Choice and Individual Values* (New Haven, CT: Yale University Press, 1963).

[2] A straightforward calculation shows that if the baby boom generation is to be paid as much as the previous generation on the basis of age and education, the U.S. gross national product (GNP) would need to grow at 2.5 percent per year. This rate of growth is needed if the baby boom generation is to fulfill its expectations for their investment in education. W.H. Esselman and O.S. Yu, "Economic Growth to Meet Income Expectations," *Journal of Policy Analysis and Management*, vol. 2, No. 1, fall 1982, pp. 111-118.

- Analysis of trends in spending patterns may not provide a good basis for anticipating spending patterns over the next two decades. Technology can create: new products and services, radical declines in the prices of existing products, an increased ability to tailor products to individual needs, new sources of information about products, new retailing methods, changes in time available for making purchases, changed tastes, and new government regulations affecting both price and quality. There is no obvious way to estimate consumer response. It is also difficult to anticipate changes in public expenditures—nearly one-quarter of all personal and government spending combined. Defining the choices Americans have about the future is necessarily an inexact process. It is essential to begin with hypotheses about how public choices could affect the structure of future consumption recipes.

The next two chapters combine a formal analysis of trends in U.S. consumption over the last two decades with an assessment of choices about the direction of future spending, which is necessarily much less rigorous. While generalizations are difficult, the discussion traces a number of themes affecting the recipe for consumption. All stem from a growth of choice made possible by increased national income, new technologies (particularly those that improve communication and those that reduce the price difference between mass-produced items and items tailored to narrow markets), and an increase in international and domestic competition. The themes include:

- the growing complexity of consumption recipes and the increased demand for sophisticated consumer decisions;
- the fragmentation of some markets into a series of niches and the integration of others into undifferentiated commodities;
- advances in communication, marketing, and retailing technologies, which can improve the match between specialized products and specialized tastes;
- the growing desire for quality in both products and services;
- the rising importance of purchased services, partly associated with an increased interest in specialized products;
- a shift of activity formerly undertaken in the home to the marketplace, such as child care, coupled with substitution of household time for services formerly provided in the market, such as VCRs for movies and home health care for hospital care;
- the growing importance of time—as opposed to money—as a constraint on the achievement of amenity for many groups; and
- persistent signs that large groups of the population fall far below standard norms in a wide range of amenities, including health, housing, transportation, and even basic nutrition.

Chapter 2 begins by defining the eight categories of amenity that, taken together, constitute most of the output of the U.S. economy. It describes recent trends in private and public spending and personal time investments used to achieve each amenity, and the major forces behind these trends: income, income distribution, demographics, prices, new technologies, new patterns of regulation, and changes in taste. The chapter examines spending at the level of the economy as a whole, focusing on the major factors that influence consumer purchasing and applying standard methods to estimate how consumption may change. Among other things, it demonstrates how demand could change as a result of changed demographics, income and income distribution, and product prices, given consumer spending that follows trends established during the past two decades.

Chapter 3 leaves the comparatively safe world of macroeconomic statistics and plunges into the admittedly qualitative issues—whether amenities such as health care, housing, and recreation are improving for Americans, and whether they are likely to improve in the future. In each of the eight amenity categories, the discussion in chapter 3 proposes a way to measure change in the basic amenity (e.g., life expectancy, morbidity rates, and infant mortality in the case of health care), and then describes the way the quality of the amenity has changed for different groups during the past few decades. It pays special attention to groups most disadvantaged by the existing distribution of resources.

Finally, building on the base established in chapter 2, chapter 3 develops "Alternative" scenarios for each amenity. These alternatives are explicitly designed to improve the quality of the amenity delivered within fixed financial constraints. Economic factors are combined with factors that could not be predicted by extrapolation alone, such as shifts in government policy and radically new technologies. Significant improvements in amenity appear to be possible in virtually every case, given the development of key technologies or changes in public regulation. It should be noted that the Alternative scenarios are speculative, and necessarily reflect some of the values of the people constructing them. Nonetheless, they may not be any less accurate than an assumption that trends in consumer behavior can be confidently extrapolated to describe the structure of demand over the next two decades.

Chapter 2

Defining the Consumption Recipe

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Chapter 2

Defining the Consumption Recipe

Americans achieve amenity through the "consumption recipe"—combining household spending for goods and services, investments of time by household members (for which no compensation is received), and government spending.[1] These recipes are in constant flux, influenced by changes in household income, in the price of goods and services, and in demographics, as well as changes in technology that can result in new products, can affect the ways producers communicate with customers, and can even influence tastes and values. Changes in values are reflected directly through new patterns of consumer purchasing, and indirectly through new patterns of public spending and regulations designed to guide private spending. This chapter reviews how these forces have shaped and may continue to shape U.S. consumption recipes.

DEFINING CATEGORIES OF AMENITY

For the purposes of the analysis that follows, all final household and government purchases are assigned to one of ten amenity categories (see box 2-A). The selection was necessarily somewhat arbitrary. Any classification scheme helps to illustrate some features of economic structure and obscure others. The categories were chosen because they cluster networks of spending where the underlying purpose is comparatively easy to describe. Chapter 3 will undertake the task of describing these purposes in ways that permit a working definition of progress in each of the first eight areas. The category of "recreation and leisure" proves to be the most difficult to define, since there is plainly an element of recreation involved with spending in all other categories. Is a walk in the park an investment in health or an investment in recreation? What about a car that is fun to drive, a home with a pleasant yard, a meal eaten in a good restaurant? The present study takes the restrictive definition of recreation used in the National Income and Product Accounts.[2]

The spending shown in box 2-A includes only personal and government spending that goes directly for the purchase of amenity. The total does not include investment and savings. In 1985, consumption categories accounted for about 85 percent of the U.S. gross national product (GNP). Most of the remainder represents investment.

The national statistical accounts, which serve as the base for of most of the data in this study, have several peculiar features that are necessarily reflected in the analysis presented here.[3] One peculiarity is the distinction made between consumption and investment. In general, anything with value after a year is considered to be a form of savings and not consumption. As applied, however, this results in a situation where spending on a gold-tiled bathroom is considered to be an investment, while money spent on education is considered consumption. Similarly, all government spending is considered to be consumption. Government purchases of research and development, roads, dams, and education are not considered a form of national investment.

National accounts are also schizophrenic in the way they treat the non-cash economy. Nearly 8 percent of GNP reported by the U.S. Department of Commerce results from the "imputed" value of services that involve no real market transaction. This value includes the imputed income that homeowners receive by "renting" houses from themselves, in itself equal to nearly 6 percent of GNP; the imputed

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[1] In most cases, the "consumption recipes" considered here can be considered equivalent to the "utility functions" used in most analyses of demand. Moreover, a number of authors have shown how time can be included in the utility equation. See, for example, G.R. Ghez and G.S. Becker, "The Allocation of Time and Goods Over the Life Cycle," working paper, National Bureau of Economic Research, New York, NY 1975.

[2] U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, July 1987, table 2.4.

[3] A formal technique to remedy some of the problems described is proposed by Robert Eisner in "The Total Incomes System of Accounts," *Survey of Current Business*, U.S. Department of Commerce, Bureau of Economic Analysis, January 1985, pp. 24-48.

Box 2-A.—The 10 Basic Amenity Groups (and as a percent of all personal and government spending on goods and services in 1985)[1]

Definition	*Percent of personal and government spending*
1. The *FOOD* category includes food and alcohol consumed in restaurants and purchased from stores. Government contributions include agricultural research and a variety of support programs for farmers.	15.1%
2. The *HOUSING* category includes everything needed for the operation of a purchased or rented home, including rent and mortgage payments, and purchases of fuel, electricity, furniture, china, draperies, housecleaning, and other goods and services used to maintain a home. Government spending goes for both housing redevelopment programs and spending for infrastructure like water and sewer systems.	19.7%[2]
3. Personal spending for *TRANSPORTATION* includes all spending for mobility, including purchases of automobiles and other personal vehicles, vehicle maintenance, gasoline, and oil; and purchases of public transportation services (air, rail, bus, and taxi). Public spending includes highway construction attributable to personal travel, and maintenance and operation of air and rail facilities.	11.4%
4. Personal consumption in the *HEALTH* category includes purchases of drugs, physicians' fees, hospital costs (including payments made by Medicare and Medicaid), and spending for health insurance. Public spending includes hospital construction and operation, and community health services.	11.4%
5. Expenditures on *CLOTHING AND PERSONAL CARE* go for products and services ranging from apparel and footwear to toiletries and beauty salons. Clothing is by far the largest item in this category, accounting for more than 80 percent of the total. There are no direct government purchases of clothing and personal care as defined here.	6.7%
6. Personal *EDUCATION* spending includes payments to private schools and colleges. Government spending includes the operation of public school systems and libraries, subsidies for colleges, and worker training programs.[3]	7.2%
7. *PERSONAL BUSINESS AND COMMUNICATION* includes personal communication by telephone and writing, as well as personal financial, legal, and insurance activities.	6.4%
8. The category of *RECREATION AND LEISURE* is particularly difficult to define. It is clear that eating out, living in a comfortable home, and transportation are to some extent recreational activities. The more restrictive definition used here includes foreign travel, hotel accommodations, social and religious activities, and purchases of books, magazines, toys, home electronics, movies, and admissions. Government contributions include the operation of parks and recreation areas.	8.9%
9. The category *DEFENSE AND SPACE* includes only Federal Government purchases of goods and services for military and space.	7.7%
10. *GOVERNMENT NOT ELSEWHERE CLASSIFIED (NEC)* includes government purchases of goods and services other than defense. Activities include the operating costs of government not directly attributable to a specific amenity group (operation of the Congress and State legislatures); transportation spending not attributable to personal travel; the court system; police, fire, and correctional institutions; and the work of authors of this study.	5.6%

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[1] In standard accounts, the "gross national product" is conventionally divided into the following components: Personal Consumption Expenditures, Government Purchases of Goods and Services, Net Exports, Gross Private Domestic Investment (consisting mostly of personal purchases of housing and business purchases of products with an expected life of more than 1 year), and an adjustment for changes in inventories. Government purchases of goods and services do *not* include transfer payments such as social security. Spending resulting from transfer payments is counted under Personal Consumption Expenditures. The spending shown in this table includes *only* personal consumption and government purchases. See the appendix for a detailed table showing how standard categories are mapped into the amenity categories shown here.

[2] The spending on housing shown here does *not* include any payments that result in an increase in the value of the U.S. housing stock from new construction or major renovation. Construction spending of this kind is considered "savings" and not consumption in conventional accounts. If purchases of new housing are included in the accounts, housing would be responsible for approximately 24 percent of the total.

[3] The accounts treat both private and public spending for education as consumption and not as a form of savings. Corporate training costs are not included.

SOURCES: Consumer purchases in these amenity categories are derived from the "Personal Consumption Expenditure" (PCE) categories used in the "National Income and Product Accounts" (NIPA), U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, July 1987, table 2.4. A precise map connecting these PCE categories to amenities is shown in the appendix. Categories of government purchases of goods and services are derived from tables 3.15 and 3.16 of the "National Income and Product Accounts." The map connecting spending categories in these tables with the amenity groups is also shown in the appendix.

rent paid by non-profit organizations that own their own buildings; the imputed value of liquidity in bank accounts and insurance funds; and the imputed value of food produced and eaten on farms.[4] The national accounts do not, however, impute the value of housework, education provided at home, or time invested by standing in line at fast food restaurants.

TRENDS IN THE CONSUMPTION RECIPE

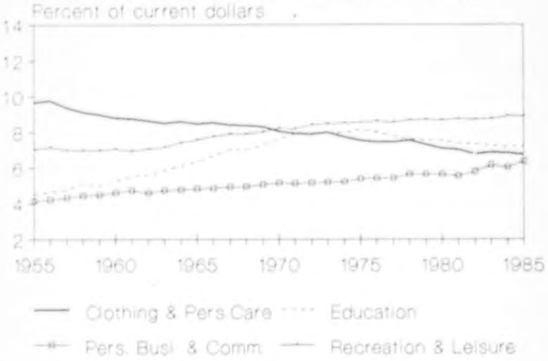
Before proceeding to examine the forces driving the change, it is worth taking a brief look at recent changes in the way Americans construct recipes to achieve amenity. These trends are described in three ways: by examining changes in overall patterns of spending for the amenities, by exploring trends in the way time was spent, and by reviewing qualitative features of spending patterns that are not adequately reflected in statistics on how Americans spend their time and money.

Consumer and Government Spending

Share of Total Expenditures

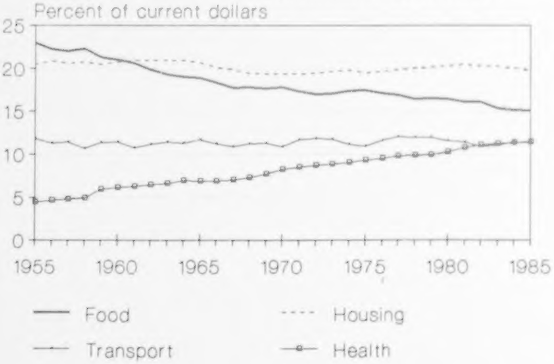
The history of household and government spending during the past three decades is traced in figures 2-1a, 2-1b, and 2-1c. Looking at trends in expenditures on each of the different amenity groups, perhaps the most striking feature of the statistics is the

Figure 2-1b.-Spending by Amenity Type (percent of all consumer and government spending)



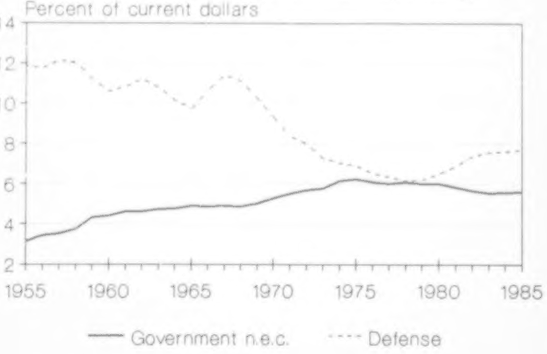
SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 2.4, 3.15, 3.16.

Figure 2-1a.-Spending by Amenity Type (percent of all consumer and government spending)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 2.4, 3.15, 3.16.

Figure 2-1c.-Spending by Amenity Type (percent of all consumer and government spending)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 2.4, 3.15, 3.16.

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[4] See U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, July 1987, table 8.9.

continued high level of personal consumption expenditure (PCE) on the most basic of amenities. Housing, Transportation, Food, Health, and Clothing and Personal Care accounted for roughly two-thirds of U.S. consumer spending in 1985, changing little since 1950. The figures show:

- a rapid and consistent decline in the percent of income spent for Food, which has been almost precisely offset by a rapid and continuous growth of Health spending (Food lost and Health care gained about 8 percent of total spending between 1955 and 1985);
- a sharp rise of spending on education followed by declines after 1975 as the baby boom generation passed through the system;
- continuous growth of spending in Personal Business (primarily financial services) and Communication, which appears to have accelerated since 1981;
- a steady decrease in the share of spending going for Clothing and Personal Care; and
- a decline in Defense spending as a proportion of all spending, which reversed in 1979.

Spending for Housing and Transportation, two of the largest categories, has remained surprisingly constant since World War II—despite large changes in the prices of energy, automobiles, and housing; in the size and characteristics of households; and in real per capita spending, which has doubled in the last 40 years. Whenever Housing costs go above 21 percent of spending, or Transportation costs go above 12 percent, a subtle alarm seems to sound. This results from a combination of factors, including historically "fixed" formulas for the percentage of gross income that borrowers can expect for mortgage or car payments.

People have apparently used discretionary income to increase the quality and variety of purchases in amenity areas like Food (through more varied eating), Transportation (through higher quality cars and more cars per family), and Clothing and Personal Care, rather than spending new income on Recreation. As a fraction of all spending, Recreation and Leisure seems to have gone through a one-time jump between 1961 and 1972, with slow subsequent increases.

Dollars and Value.—The previous discussion showed how Americans spent their income in any given year in "current dollars"—values measured in the currency of the year in which the data was collected. The statistics say little about either the quality or the quantity of the products and services purchased, since many relative prices changed rapidly during the period shown. Legal services that cost $1,000 in 1955 might still be considered worth the price in 1987, but a computer equivalent to one that cost $1,000 in 1955 would be worth very little in 1987. The effects of inflation can, in principle, be removed from product prices by converting spending to "constant dollars." Converting current into constant dollars involves the vexing problem of developing a consistent set of prices for goods and services of constant quality. This process becomes more difficult during periods of rapid technological change. It can also become more difficult as a greater fraction of economic activity involves activities like legal services, where quality is inherently more difficult to measure (see discussion in ch. 5).

Most of the qualitative features of figures 2-1a to 2-1c remain when spending is converted into constant dollars (see figure 2-2), with one important exception: in constant dollars, spending on Clothing and Personal Care has risen sharply since the mid 1970s. Constant dollar spending by government for amenities cannot easily be estimated, since data is not collected on "constant quality" government services in much detail.[5]

Another way to view the changes in average prices that have occurred during the past three decades, compared to changes in average incomes, is to see how long it has taken an average full-time worker in America to earn enough to buy items of comparable quality during the past few decades. In this respect, most manufactured goods have become a bargain while the real price of most services has changed little (see table 2-1). A television set that could be bought for 1 day's work in 1972 needed over 4 days' work in 1950 and only 4 hours' work in 1986. Clothing, new cars, and communication services showed strong declines. On the other hand, most forms of medical services now require more work to purchase than was the case in 1950.

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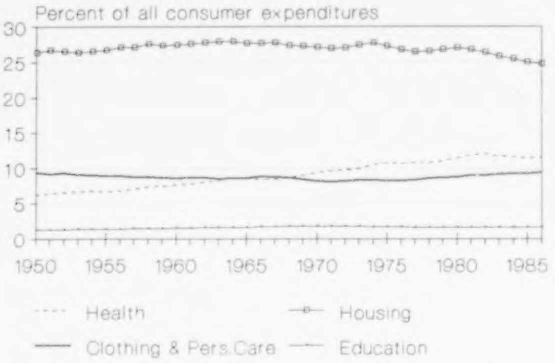
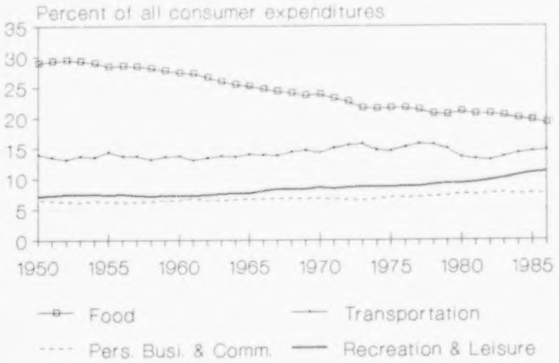
[5] For years in which data is available, constant dollar estimates of government spending can be computed by converting government spending in each category to spending in commodity categories for which output deflators are available. This could not be done for most of the period shown in figure 2-2.

Figure 2-2a.-Constant Dollar Shares of Consumer Spending on Health, Housing, Clothing & Personal Care, and Education



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 2.5.

Figure 2-2b.-Constant Dollar Shares of Consumer Spending for Food, Personal & Business Communication, Transportation, and Recreation & Leisure



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 2.5.

Patterns of price reduction have also changed over time. Between 1950 and 1970, there was a significant decline in the amount of work needed by the average worker to make all purchases. Of the items listed in table 2-1, only mass transit required more labor to buy in 1970 than in 1950. Since 1970, however, many items require more work to purchase.

Spending on Services.—Attempts to separate "services" from "goods" have never been completely satisfactory. The category "services" combines housecleaning, brain surgery, banking, and car repair. Most amenities are satisfied by a complex combination of purchased goods and services. Later chapters will show the extent to which even manufactured products embody non-manufacturing "service" activities. However defined, services represent an increasing fraction of consumer expenditures. The price of manufactured goods has declined much faster than that of services (table 2-1), while demand for services appears to have increased rapidly with rising incomes.

The curious pattern of decline and growth in demand for services between 1930 and 1986 is charted in figure 2-3. Rising from a low of less than one-third of all constant dollar spending at the end of World War II, services now command more than 40 percent—even given a comparatively narrow definition. Most recent growth in demad has not resulted from purchases of personal services like housekeeping, but rather from purchases of medical care, education, and professional services like banking, law, and insurance.

Savings and Investment.—In recent years, personal and government consumption has grown as net savings have declined. Figure 2-4 illustrates the decline in national savings rates during the past decade or so, measured as a percentage of GNP. A slight increase in rates of business savings, taken as retained earnings and in other ways, has been more than offset by a sharp decline in net government savings—the budget deficit—and by the drop in personal savings. Gross savings fell from over 18 percent of GNP in 1979 to about 13.5 percent in 1986. As will be outlined in chapter 8, this savings shortfall has been offset by large foreign investments in the United States.

The Private/Public Mix

The mix of public and private spending used to purchase amenity differs greatly from one part of the economy to another (see table 2-2). Taken together, public spending categories together have held a surprisingly constant share of total spending for three decades. The combination of spending directly related to the first eight amenity groups, Defense, and Government spending not elsewhere classified has remained near 23 percent of all spending since 1955, with a brief excursion to 26 percent during the Viet Nam War. Defense purchases fell steadily as a fraction of all current dollar spending toward the end

Table 2-1.—Change in Time Needed by the Average[a] American To Purchase Goods and Services
(time worked to buy item in 1972 = 1.0)

Item purchased	1950	1960	1970	1980	1986
Radio and television receivers	4.09	2.20	1.13	0.63	0.39
Women's and children's clothing	2.02	1.36	1.07	0.71	0.55
Shoes	1.47	1.24	1.07	0.85	0.68
Telephone and telegraph	2.21	1.63	1.03	0.66	0.72
Durable goods (average)	2.42	1.66	1.09	0.88	0.75
Recreation (BEA definition)	1.37	1.21	1.06	0.86	0.80
New autos	2.18	1.72	1.10	0.90	0.81
Admissions to spectator events	1.19	0.99	1.05	0.87	0.87
Nondurable goods (average)	1.80	1.34	1.06	1.04	0.90
Food (grocery)[b]	1.80	1.35	1.06	1.06	0.94
Average personal consumption	**1.75**	**1.35**	**1.05**	**1.00**	**0.96**
Transportation[c]	1.39	1.20	0.99	1.02	0.99
Homeowning[d]	1.72	1.40	1.05	0.94	1.01
Transit systems	0.85	0.94	1.02	0.81	1.02
Home renting	1.72	1.40	1.05	0.94	1.03
Drug preparations and sundries	2.40	1.80	1.11	0.89	1.04
Food (restaurants)[e]	1.25	1.02	1.01	1.01	1.07
Gasoline and oil	1.98	1.54	1.11	1.89	1.08
Health insurance	1.28	0.91	0.90	0.72	1.08
Airline	1.82	1.34	1.03	1.23	1.17
Personal business[f]	1.28	1.09	1.02	1.09	1.20
Medical care (all private)	1.15	1.05	1.02	1.08	1.21
Privately controlled hospitals	1.11	1.06	1.04	1.13	1.23
Household electricity	2.22	1.53	1.02	1.19	1.25
Physicians	1.13	1.05	1.03	1.12	1.28
Household gas	1.73	1.46	1.01	1.66	1.82

How To Read This Table: The fraction of television and radio receivers that could have been purchased for 1 day of work in 1972 would have required 4.09 days of work to purchase in 1950 and 0.39 days of work to purchase in 1986.

NOTE: The categories are a representative sample and not a complete set. They are ranked by growth in the ratio between 1972 and 1986. For details, see table 2.4 of the National Income and Product Accounts.

[a] "Average" defined by average wage and salary earnings per full-time equivalent employee.

[b] Food purchased for off-premise consumption.

[c] Not including vehicle purchases.

[d] Mortgage payments less payment for equity.

[e] Food purchased for on-premise consumption.

[f] Bank service charges, insurance (non-health), brokers.

SOURCE: Based on U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business* historical diskettes, tables 6.8b and 7.10, July 1987.

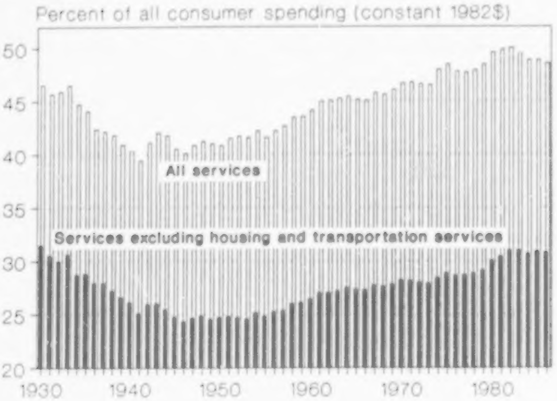
of the Viet Nam War (figure 2-1c) while civilian spending increased. The trend was reversed in 1979 but Defense spending remains below the share it held during the 1955-68 period.

In most cases, patterns of purchasing have been comparatively stable. By long tradition, for example, government pays for roughly 85 percent of all Education; privately supported education has not made serious inroads. There have, however, been some changes in the mix of public and private spending. In Transportation, though most highways and some other transportation infrastructure are purchased publicly, many private developers have recently been required to build roads, sewers, parks, water supplies, sidewalks, and other infrastructure formerly provided at public expense. Table 2-2 indicates a sharp decline in government spending on highway construction and other infrastructure. It also shows the effect of declines in support for Housing and parks (in the Recreation and Leisure category) that occurred in 1980.

Time

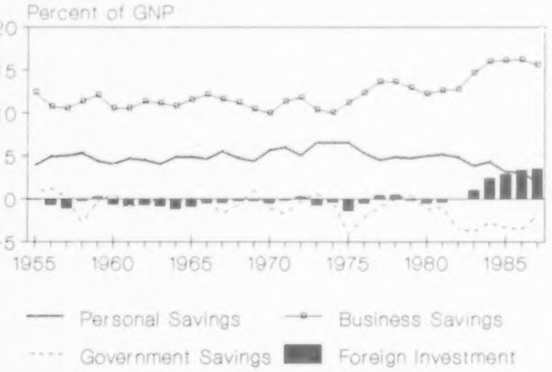
Incomes can increase due to productivity, but time available to spend that income remains fixed unless the economy moves to shorter work weeks and longer vacations. If anything, however, Americans are working harder and longer than they have in the recent past. Increased female participation in the work force has meant that many chores once purchased through unpaid "housewife" time (child care,

Figure 2-3.-Share of Consumer Spending on Services



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 2.5.

Figure 2-4.-Savings and Investment by Type



How To Read This Table: In 1986, personal savings (investments in savings accounts, stocks, etc.) fell to 3% of GNP. The U.S. economy received more investment money from foreigners (nearly 4% of GNP in 1986). Because of the government deficit, government savings were a negative 3% of GNP. Net business savings (retained earnings, depreciation, etc.) rose to 16% of GNP.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 5.1.

care for the elderly, and even cooking) are now bought in the market.

Technology has made it possible to move many activities formerly available only through the marketplace into the home. The private automobile continues to replace purchased transit. The video cassette recorder and other home electronic equipment are substituting for entertainment purchased away from home and seem to have had an impact on many of the social clubs and organizations that once occupied a significant amount of American time. Cost containment in health care, combined with the emergence of elaborate home care equipment, has forced many kinds of health delivery out of the hospital and into the home. Interest in self-administered health promotion, such as diet and exercise programs, has grown. Direct marketing—using 800-numbers, credit cards, home shopping networks, and the United Parcel Service—has risen dramatically. In effect, technology has "capitalized" household time to make it more productive. But while this has increased the productivity and decreased the burden of housework in principle, real savings are difficult to find.[6]

Personal investment in self-training appears to have increased as well, in areas related to both employment and recreation. Home information is one of the most curious examples. In the past, information acquired from radio and television broadcasting was purchased primarily through unpaid investment of a consumer's time—waiting through commercials. The consumer bought only the receiver. Purchases of information in the form of cable television and video cassettes (including rentals), however, are beginning to approach the total value of equipment sales.

Trading Time and Money

A number of attempts have been made to understand how individuals trade personal time against time spent in the marketplace.[7] Will an individual choose to work fewer hours and enjoy more leisure as a result of higher wages, and is it institutionally possible to do so? Alternatively, will a person with a higher income feel that the effective cost of leisure time is also high and prefer to work longer? The choice requires an understanding of the way individuals substitute leisure time for goods, but theory does not pretend to predict an answer and available

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[6] J. Vanek, "Time Spent in Housework," *Scientific American*, vol. 231, 1974, pp. 116-120.

[7] See J.D. Owen, *Working Lives* (Lexington, MA: Lexington Books, 1979); G.R. Ghez and G.S. Becker, op. cit., footnote 1. Early work on trade-offs between leisure time and work time can be found in Lionel Robbins, "On the Elasticity of Income in Terms of Effort," *Economica*, No. 10, pp. 123-29, 1930. Also see discussion in ch. 11 tying income to the desire for more or less work.

Table 2-2.—Government Spending as a Percent of Final Consumption in Each Amenity Group
(current dollars, in percent)

Amenity	1955	1965	1975	1985
Food	2.6%	0.7%	1.4%	3.8%
Housing	1.5	2.5	2.9	2.0
Transportation	11.3	13.1	11.8	9.1
Health	6.0	19.7	22.1	17.5
Clothing and Personal Care	0.0	0.0	0.0	0.0
Education	82.5	84.0	85.2	82.7
Personal Business and Communication	0.0	0.0	0.0	0.0
Recreation and Leisure	2.2	2.9	4.2	3.3
Defense	100.0	100.0	100.0	100.0
Government n.e.c.	100.0	100.0	100.0	100.0
Total (GNP)	21.4	23.7	24.6	23.5

How To Read This Table: In 1955, 2.6 percent of all final consumption of Food resulted from Federal, State, or local government purchases of goods and services related to this amenity.

NOTE: The large increase in government spending for the Health amenity between 1955 and 1965 resulted from a redefinition of this category between 1958 and 1959.

SOURCE: Based on U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, tables 2.4, 3.15, and 3.16, July 1987.

behavioral evidence is ambiguous. An obvious shortcoming of conventional approaches to the issue is that they assume workers do not derive any satisfaction from their jobs[8] (see ch. 11 for a discussion of these issues).

Trends in Time Use

There have been many changes in how time is divided between work, including housework, and leisure. Comparisons between time use surveys conducted in the 1930s and the 1960s, for example, show considerable increases in work time and decreases in free time. One of the major areas of growth in work time was housework, in particular the time spent shopping and traveling on household errands. It appears that the impact of the deluge of time- and labor-saving home appliances during this period was to lengthen rather than shorten the amount of time spent on housework.[9]

Between 1965 and 1975, however, Americans experienced considerable gains in free time and declines in the amount of time spent both working for pay and working in the home. More women were working for pay, but on average they were working considerably fewer hours than before.[10] Time spent on housework also declined considerably, by 20 percent overall. The combined decline in labor market time of about 40 minutes per day and in housework of about 14 minutes per day resulted in a 10-percent increase in leisure time.

What were Americans doing with their increased free time during this period? Primarily, they were watching television. On average, TV viewing time in 1975 totaled about 14.7 hours per week, the equivalent of all time spent on housework and 1.5 times as much as time spent eating. TV viewing constituted 50 percent of all leisure, and more than 60 percent of all time spent on "passive leisure."

More recent time use data, collected in 1985, suggest that over the past decade the use of time has changed once again (see table 2-3).[11] A sharp increase in work time, largely the result of women working longer hours, is mirrored by a decline in free time.[12]

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[8] Tibor Scitovsky, *The Joyless Economy* (Oxford: Oxford University Press, 1976).

[9] The impact of new home technologies on time use is complicated. C.L. Long, *Labor Force Under Changing Income and Employment* (Princeton, NJ: Princeton University Press, 1958), argued that improved household technologies made women more productive in the home and increased female leisure, thereby freeing them for more market work. However J. Vanek, in "Time Spent in Housework," op. cit., footnote 6, refuted the notion of increased household productivity.

[10] John P. Robinson, "Changes in Americans' Use of Time: 1965-1975: A Progress Report," Communications Research Center, Cleveland State University, August 1977.

[11] John P. Robinson, "Trends in Americans' Use of Time: Some Preliminary 1975-85 Comparisons," Survey Research Center, University of Maryland, December 1986.

[12] Data provided by the U.S. Bureau of Labor Statistics indicate that the number of hours worked per adult grew at a slower rate than that captured in the survey discussed here, due largely to earlier retirement among older men, which has tended to offset the entry of women into the U.S. work force (see discussion in ch. 11). This time use survey however, does not capture the offsetting effects of earlier retirement, primarily because the number of men surveyed who were over age 55 did not constitute a statistically significant sample.

Table 2-3.—Weekly Time Budgets: Men and Women, 1975 and 1985 (in hours)

	1975			1985			Change in hours 1975 v. 1985		
	Men	Women	Average	Men	Women	Average	Men	Women	Average
Contracted time	32.9	14.5	23.7	33.2	21.3	27.3	0.3	6.8	3.5
work	30.0	13.4	21.7	29.6	19.3	24.5	−0.4	5.9	2.7
travel to work	2.9	1.1	2.0	3.6	2.0	2.8	0.7	0.9	0.8
Committed time	15.6	33.1	24.3	16.6	28.6	22.6	1.0	−4.5	−1.7
housework	8.1	21.6	14.8	9.4	17.7	13.5	1.3	−3.9	−1.3
child care	1.0	3.6	2.3	0.8	3.0	1.9	−0.2	−0.6	−0.4
shopping	2.7	4.1	3.4	2.8	4.1	3.5	0.1	0.0	0.1
family travel	3.8	3.8	3.8	3.6	3.8	3.7	−0.2	0.0	−0.1
Personal time	75.3	78.6	76.9	75.9	79.6	77.7	0.6	1.0	0.8
eat at home	6.6	6.6	6.6	6.3	5.8	6.1	−0.3	−0.8	−0.5
eat out	3.0	1.9	2.4	2.3	2.0	2.1	−0.7	0.1	−0.3
personal care	65.7	70.1	67.9	67.3	71.8	69.5	1.6	1.7	1.6
Free time	44.2	41.6	42.9	42.1	38.3	40.2	−2.1	−3.3	−2.7
education	3.0	1.8	2.4	2.6	1.7	2.1	−0.4	−0.1	−0.3
organization	1.4	2.4	1.9	1.4	1.7	1.5	0.0	−0.7	−0.4
social	6.9	7.0	6.9	5.5	4.7	5.1	−1.4	−2.3	−1.8
recreation	4.7	4.5	4.6	5.0	4.1	4.5	0.3	−0.4	−0.1
electronic med	18.4	15.9	17.1	17.2	15.6	16.4	−1.2	−0.3	−0.7
other media	6.6	7.5	7.1	6.6	7.8	7.2	0.0	0.3	0.1
leisure travel	3.2	2.5	2.9	3.8	2.7	3.3	0.6	0.2	0.4

SOURCE: John P. Robinson, "Trends in Americans' Use of Time: Some Preliminary 1975-85 Comparisons," Survey Research Center, University of Maryland, December 1986, p. 34.

All age groups of women have increased their hours of paid work by about 6 hours a week, while there has been relatively little change in the numbers of hours of paid work for men. The increase among women was offset to some extent by a decline in hours of housework, but there was also an average loss of more than 3 hours per week in women's leisure time. In fact, women in most age groups have 5 to 6 hours less leisure time per week than men. The exception is the 35 to 54 age group, where men and women appear to have the same amount of leisure time. Ten years ago, women had more leisure time than men in this age group.

There have also been changes in how leisure time is used. The two largest uses of leisure time are social activities and electronic media. Time spent in social activities declined by 26 percent between 1975 and 1985. Television viewing, expressed in the table as part of "electronic media," also declined by varying amounts among the different age groups. At the same time, a sharp increase in time spent in telephone conversations was recorded. For example, time spent on the telephone doubled for men aged 25 to 44, and increased by 10 percent for men over 65. Although there has traditionally been a gender gap in the use of the telephone, by 1981 this difference disappeared in the youngest age cohort.

Allowing for statistical vagaries, Americans seem to spend more days and more hours on the job per day than is the norm for industrialized nations. Between 1953 and 1983, average weekly hours worked by U.S. production workers remained virtually constant, moving from 40.7 to 40.1 with only minor fluctuations. During the same period, however, hours in other industrial countries decreased, often markedly. Canadian workers averaged 40.1 hours in the mid 1950s against 37.1 in 1982, during which time the Italians declined from 44.7 to 37.7 hours and Belgian averages fell from 41.6 to 31.7. Between 1965 and 1983, the French average declined from 45.8 to 39.3. The West Germans, Dutch, and British workers now work more hours than their U.S. counterparts (40.3 to 40.6 hours in 1983). The Japanese worked 41.1 hours.[13]

Long commutes also constrict American leisure. The United States shares with Australia the second lowest percentage of people commuting to work 15 minutes or less (36 percent), exceeding only the Netherlands (21 percent).[14]

Vacation time and paid leave offer other indications of the character of Americans as workers. The United States has, with the enactment of Martin Luther King Day, nine national holidays, with additional holidays particular to some States such as Patriots' Day in New England. This is lower than all but 2 of 14 OECD (Organization for Economic Cooperation and Development) nations surveyed.[15] Unlike most of OECD, the United States does not impose a legal minimum of compensated leave.

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[13] U.S. Department of Labor, Bureau of Labor Statistics, *Handbook of Labor Statistics*, Bulletin 2217, Washington, DC, June 1985.

[14] Organization for Economic Cooperation and Development, "Living Conditions in OECD Countries: A Compendium of Social Indicators," OECD Social Studies No. 5, Paris, 1986, p. 85.

Time and Consumer Decisions

The amount of free time available also affects the quality of purchasing decisions made by Americans.[16] Conflicting forces are again at work. On the one hand, future consumers are likely to be better educated than those of earlier generations, and will have a wide range of new technologies available for gaining access to information. On the other hand, consumers are likely to have less time to analyze information and make major decisions. Increased incomes, dual earner households, and the growing complexity of choice resulting from diversified product offerings means that decisions are becoming more frequent and more difficult while less time is available to make them.[17] In fact, many retailers find that major purchasing decisions are being made by teenagers whose parents may have little time to shop.[18]

While imperfect consumer decisions that result from minimizing the time spent collecting and analyzing information may be a rational response by individuals, society as a whole may pay a much greater price.[19] This raises a number of real challenges for those wishing to forecast the future of consumer spending.

Qualitative Factors

The data just cited provide a crude guide to changes in the ways Americans spend their income and time—changes whose influence on the structure of the economy as a whole will be illustrated in later chapters. As spending has moved further from needs and necessities to decisions reflecting a range of tastes and choice, it has generally been distributed in familiar ways. Americans spent about one dollar in five on Housing in 1950 and the same fraction in 1986, in spite of the fact that real per capita income more than doubled during the period.

Many factors in the structure of household and government demand that affect the quality of amenity achieved, as well as the structure of producing enterprises, are not well reflected in these statistics. They include such things as changes in the *quality* of the houses purchased, the *type* of food Americans eat, and the *kinds* of cars they drive. These issues are discussed at much greater length in chapter 3. One general observation, however, deserves attention. Many markets formerly dominated by a comparatively small number of relatively homogeneous products are becoming "boutique" markets, combining a wide range of specialties. There are, of course, markets for low-priced commodities—but the "low cost, vanilla-flavored product" is now itself a kind of niche.

Chapter 3 will demonstrate that specialization is replacing commodity-like products in a remarkable variety of markets—and will suggest a number of areas where specialization is likely to grow rapidly. Financial packages in areas such as insurance and investment can be designed and analyzed rapidly by trained people working with a computer terminal. The mass media are becoming differentiated, as specialized magazines replace such publications as the *Saturday Evening Post*. An industry directory indicates that there were 11,000 periodical titles in 1986, an increase of 60 percent from 1985.[20] Broadcast television has had its market fragmented by cable TV and video cassette recorders. Eating habits have diversified, as both restaurants and larger groceries cater to a wider variety of tastes.

This product differentiation is driven by a variety of factors, including the growing diversity of American households, the movement of comparatively well-educated baby boomers into their peak earning years, and technology that allows both production of specialized products without an enormous price premium and highly targeted advertising.[21] However, it proves difficult to disentangle cause and effect. It is likely, for example, that the demand for tailored products was always latent but difficult to express because of the large cost premiums involved. Changes in taste also play a role, but are far harder to document.

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[15] Ibid., p. 89.

[16] One of the central assumptions in much economic analysis is that consumers are perfectly informed and rational in the way they make decisions, that this information is free, and that any defects in decisionmaking will continue into the future. There is now a considerable literature discussing defects in this assumption. The defects are not particularly important if the degree or the significance of misinformation do not change significantly over time. The discussion in ch. 3, however, shows many places where significant changes may occur in the way consumers obtain and use information.

[17] S.B. Linder, *The Harried Leisure Class* (New York, NY: Columbia University Press, 1970).

[18] C. Russell, "The New Homemakers," *American Demographics*, October 1985, p. 23.

[19] Tibor Scitovsky, op. cit., footnote 8.

[20] The directory includes titles like: *Walking, Running, Wildfowl Carving, Gambling Times, Vegetarian Times, North Texas Golfer, Croquet Today*, and *The Quarterly Magazine of The Rocky Mountain Elk Foundation*. See S. Fatsis, "A New Leaf: Magazine Industry Flourishing," Associated Press, Oct. 11, 1987.

It does little good to produce for a specialized market if it is impossible to market the product within that niche. New technology, however, has also changed the way that producers can reach specialized markets. Printing and mailing catalogs to specialty lists has become an enormously sophisticated enterprise. The Montgomery Ward catalog has given way to a plethora of specialized pamphlets. Active consumer participation in the design of products, including information products, is another likely development. Homes can be designed, with the assistance of a skilled salesman, on a computer in showrooms. Even clothing may soon be tailored at an affordable price using robotic sewing equipment. As later chapters will show, the shift to specialized goods and services is having a profound impact on the structure of the business networks that produce amenities. In particular, technologies that appear to have economies of scale in a situation where demand is predictable may perform poorly in a rapidly changing market. A flexible production system may use equipment with comparatively inexpensive "set-up" times and small truck deliveries instead of bulk freight, even though these systems appear to be less productive than those they replace.

FORCES AFFECTING THE CONSUMPTION RECIPE

The changes in spending patterns just described have been driven by a variety of forces that will continue to play a powerful role in shaping future recipes of consumption. Demographic factors, such as changes in the number and type of American households, the aging of the baby boom generation, and the growing number of elderly people, will affect spending patterns, as will changes in household income, income distribution, and prices.

The following discussion examines these forces in some detail, in order to develop a portrait of how Americans may spend their money in the future—assuming that such an estimate can be derived from data on demographics, income, and prices. This allows for the creation of "Trend" scenarios, using standard extrapolative techniques to project spending patterns. These Trend cases will also serve as the basis for the "Alternative" scenarios, which will be described at some length in chapter 3. The Alternatives make assumptions about the role of new products, new regulations, new values, and other factors that may not be captured in standard statistical series—however clever the extrapolation technique.

Households

National averages can provide a grossly misleading view of national living standards. Every American household has its own needs and resources, and its own recipe for happiness. Depending on its nature, economic growth can benefit some groups but not others. One way of looking below the veil imposed by averages is to examine spending patterns by household type and household income.[22] Household analysis is also needed to understand how well the economy is meeting the needs of a diverse population, and how it is serving those most likely to be disadvantaged.

Trends in the Formation of Households

Characteristics of households have changed rapidly over the past two decades, following changes in both the age structure and lifestyle of the population. The average American household shrank from 3.33 people in 1960 to 2.65 in 1983 and has continued to decline, largely as a result of the striking increase in the number of people living alone. The number of all single households has nearly doubled since 1960 and amounted to nearly one-quarter of all such American households in 1983; the share of young singles grew over 60 percent between 1972 and 1983 (see table 2-4). One in every eleven Americans now lives alone. Since the average size of a household is shrinking, the total number of households has grown more rapidly than the U.S. population in recent decades.

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[21] See also Aimee L. Stern, "The Baby Boomers Are Richer and Older," *Business Month*, October 1987, pp. 24-28.

[22] See, for example, Roberta Barnes and Robert Gillingham, "Demographic Effects in Demand Analysis: Estimation of the Quadratic Expenditure System Using Microdata," *The Review of Economics and Statistics*, No. 591, 1984; and Robert Gillingham, "Measuring the Cost of Shelter for Homeowners: Theoretical and Empirical Considerations," *Review of Economics and Statistics*, vol. LXV, No. 2, 1983.

At the same time, significant changes in lifestyle have taken place. The post-war era has seen more women join the work force, incomes rise, a growth in divorce rates, and an increase in the number of young Americans who have decided to live away from home. These factors are giving a new look to the American household. Only about one-fifth of American households now include a working father, a housewife, and children,[23] down from nearly one-third in 1972. As table 2-4 indicates, all categories of married couples under age 65 have declined in share since 1972—when the oldest members of the baby boom were 26, an age after which the traditional expectation would be an *increase* in the share of married couples.

Table 2-4.—The Composition of Consumer Households: 1972, 1983, and Estimates for 2005 (in percent)

Household (HH) type	Percent of total		
	1972[a]	1983	2005
Singles	11.5%	15.2%	14.7%
Age 15-34	4.2	6.9	4.9
Age 35-64	7.4	8.3	9.8
Elderly (65+)	19.2	20.3	20.7
Single	8.3	8.9	9.1
Couples	10.9	11.4	11.6
Couples	58.0	47.4	48.4
No children	16.9	14.0	14.5
Child <6 years old	9.2	7.4	5.8
Child 6-17 years old	20.8	16.0	16.3
Child >17 years old	11.1	10.0	11.8
Single parent	5.1	6.6	5.9
Other	6.2	10.5	10.3
Unrelated adults	1.5	4.0	3.3
Other	4.7	6.5	7.0
Total (percent)	100.0	100.0	100.0
Total (millions of HH)	69.3	88.8	118.6

[a] 1972 shares correspond to "families," as defined by the U.S. Bureau of the Census' "Consumer Population Survey." For the 11 household types, the differences in 1983 share between "families" and "consumer households" were all less than 1 percent.

NOTE: Totals may not equal 100 due to rounding.

SOURCES: 1972 figures taken from U.S. Bureau of the Census, "Consumer Population Survey;" 1983 and 2005 figures taken from "Household Formation Program," working paper prepared for the Office of Technology Assessment, Washington, DC, May 1986.

Indeed, the baby boom generation, born just after World War II, has played a major role in reshaping American demographics, and its weight will continue to be felt as its ranks pass through different age cohorts. In 1960, 41 percent of the population was under the age of 21. By 1982, this figure had fallen to 34 percent. Other age groups have become more populous as the median age of the population has risen.

The demographic model used for this analysis[24] indicates that during the next 20 years the number of U.S. "consumer households"[25] will increase by about one-third—an average annual increase of 1.3 percent (again see table 2-4). This is a higher rate of increase than that of total population because of an expected continuing decline in household size. The distribution of major consumer household categories should remain fairly stable, with the largest change on the order of 1 percent (married couples under age 65). The distribution of types within categories, however, will shift somewhat, due to the aging of the baby boomers. Single consumer households age 35 to 64 and married couples with children over 17—the two groups in which baby boomers will be counted most frequently in 2005—will increase more than any other type; at the same time, young singles and couples with children under 6 will lose share.[26]

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[23] C. Russell, op. cit., footnote 18.

[24] "Household Formation Program," working paper prepared for the Office of Technology Assessment, Washington, DC, May 1986. See box 2-B and the appendix for more detail. For other projections of household composition, see U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 986, "Projections in the Number of Households and Families: 1986-2000" (Washington, DC: U.S. Government Printing Office, 1986); John R. Pitkin and George S. Masnik, "Households and Housing Composition in the United States, 1985 to 2000: Projections by a Cohort Method," Joint Center for Housing Studies of MIT and Harvard University, Research Report RJ86-1, Cambridge, MA, 1986; and Patricia H. Hendershott, "Household Formation and Home Ownership: The Impact of Demographics and Taxes," National Bureau of Economic Research, Working Paper No. 2375, Cambridge, MA, September 1987.

[25] The term "consumer household" in this analysis is used in place of the term "consumer unit" used by the U.S. Bureau of Labor Statistics. A "consumer household" is "a single person or group of persons in a sample household related by blood, marriage, or adoption or other legal arrangement, or who share responsibility for at least two out of three major types of expenses—food, housing, and other expenses." Consumer households are divided into 11 "household types," for which trends and scenarios on composition and spending are developed. See "Household Formation Program," working paper prepared for the Office of Technology Assessment, Washington, DC, May 1986. The term "consumer household" is used in this discussion to differentiate it from the generic term "household," used in other parts of ch. 2.

Consumer households (or consuming units) should not be confused with other precise definitions of "households" or "families." As defined by the U.S. Bureau of the Census, "Current Population Survey" (CPS), Technical Documentation, March 1984, a "household" is as follows: "A household consists of all the persons who occupy a house, an apartment, or other group of rooms, or a room, which constitutes a housing unit. A group of rooms or a single room is regarded as a housing unit when it is occupied as separate living quarters; that is, when the occupants do not live and eat with any other person in the structure, and when there is direct access from the outside or through a common hall" (this does not include "group quarters" like rooming houses, military barracks, or institutions).

Spending by Type of Consumer Household

Data describing expenditure by type of consumer household are sparse. The primary source is the U.S. Bureau of Labor Statistics' "Consumer Expenditure Survey" (CES), which uses only a small sample and suffers from a number of other drawbacks—there was no survey taken between 1972/73 and 1982/83. If the CES data are used in an aggregated form, however, they give reasonable results, and the 1982/83 survey is used as the basic household database in this study.[27]

Table 2-5 shows how different consumer households spent their money in 1972/73 and 1982/83. Housing costs represent a significant fraction of the spending of couples with young children, singles, and single parents; housing captured the highest fraction of spending among single elderly households. Not surprisingly, smaller households spend more per capita on housing than their larger counterparts. The share of spending devoted to housing has increased since the 1972/73 CES survey for all but two consumer household types.

Per-person expenditures on food are high in single consumer households, which do not benefit from economies of scale in food preparation. Within the food category, young singles and childless couples both spend far more on food away from home than their larger and/or older counterparts, although all households spend a smaller fraction of their incomes eating out than cooking at home. Still, in households headed by someone 34 years of age or less, almost half of all expenditures on food are away from home, compared with 27 percent in the over 65 group. Similarly, per capita spending for away-from-home entertainment is higher for younger singles and childless couples than for the elderly. On the other hand, spending on air fares, hotels and motels, home electronic and other devices, and alcohol increased for every household type.

Out-of-pocket medical expenses increased sharply for the elderly during the 1970s and early 1980s, and remain much higher than for other cohorts; health care also became a greater burden for single parents. Out-of-pocket spending for education increased for most consumer household types; the increases were particularly dramatic for young singles and single parents, while parents with children of college age continued to spend more on education than any other group. All household types increased the percentage of spending on personal business and communication, while the converse was true for spending for clothing and personal care.

The proportionately greater spending that the single elderly devote to housing and medical care reduces the money they can spend elsewhere. Not surprisingly, the single elderly, a group with comparatively little mobility, devote fewer resources to transportation and recreation and leisure than other groups, while the share going to personal business—largely time spent on the telephone—is greater than that of any other.

Income

Household income affects not only the level but also the type of expenditures made by Americans. As incomes increase, families typically spend a smaller proportion of their income on food—though

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The consumer household is also distinct from the CPS "family," which is defined as "a group of two persons or more (one of whom is the householder) residing together and related by birth, marriage, or adoption." There may be several families in a single household.

[26] It should be noted that the number of elderly households will begin to increase rapidly after 2011, 6 years beyond the scope of the scenarios used in this analysis.

[27] Expenditure categories for consumer households are taken from the "Consumer Expenditure Survey," and are not an exact match with the amenity categories outlined earlier in this chapter. See "Consumer Expenditure Demand Projection Program," working paper prepared for the Office of Technology Assessment, April 1986. For more detail, see the appendix.

Table 2-5.—Spending by Consumer Household Type, 1972-73 and 1982-83 (current dollars, in percent)

Household type	Food	Housing	Transportation	Health	Clothing and Personal Care	Education	Personal Business and Communication	Recreation and Leisure	Total
1972-73:									
Singles:									
Age 15-34	18.0	33.3	25.6	2.4	9.4	0.7	3.2	7.3	100.0
Age 35-64	24.6	33.2	17.7	4.9	9.8	0.2	3.6	6.0	100.0
Elderly:									
Single	25.2	39.6	10.6	9.1	7.6	0.1	3.4	4.3	100.0
Couples	27.8	27.5	18.6	9.6	8.0	0.6	2.7	5.3	100.0
Couples:									
No children	22.0	28.0	24.7	5.2	9.7	0.6	2.6	7.2	100.0
Child <6	19.5	35.2	22.2	5.3	8.7	0.6	2.6	5.9	100.0
Child 6-17	26.9	27.9	20.8	4.9	9.8	0.9	2.1	6.6	100.0
Child >17	25.9	22.0	25.7	4.8	9.9	3.5	2.0	6.1	100.0
Single parent	26.3	35.6	15.1	3.3	10.8	1.2	3.1	4.6	100.0
Other:									
Unrelated adults	24.6	27.6	22.8	5.5	9.6	2.2	2.8	4.9	100.0
Other	27.6	26.3	21.9	5.2	10.0	1.0	2.5	5.6	100.0
1982-83:									
Singles:									
Age 15-34	21.1	32.7	22.3	2.8	7.3	2.9	3.7	7.3	100.0
Age 35-64	21.7	36.9	20.5	4.0	6.7	0.3	4.2	5.7	100.0
Elderly:									
Single	21.6	40.1	11.0	12.7	5.9	0.2	5.1	3.4	100.0
Couples	24.2	28.9	20.4	10.8	6.4	0.5	3.3	5.5	100.0
Couples:									
No children	20.7	30.7	25.4	4.6	7.3	1.2	3.2	6.9	100.0
Child < 6	19.5	36.9	22.5	3.8	6.7	1.8	2.7	6.1	100.0
Child 6-17	22.8	30.2	22.8	3.8	7.6	2.1	2.6	8.0	100.0
Child >17	23.9	24.6	26.5	4.4	8.2	3.4	2.9	6.2	100.0
Single parent	24.1	32.9	18.4	4.1	8.5	2.3	4.3	5.4	100.0
Other:									
Unrelated adults	21.9	29.0	27.4	4.2	6.8	0.9	4.4	5.4	100.0
Other	25.2	30.8	20.9	3.8	8.3	1.5	4.0	5.5	100.0

NOTE: Totals may not add to 100 due to rounding.

SOURCES: For household types, see "Household Formation Program," working paper prepared for the Office of Technology Assessment, Washington, DC, May 1986; for expenditure categories, see U.S. Bureau of Labor Statistics' "Consumer Expenditure Survey," 1972/73 and 1982/83.

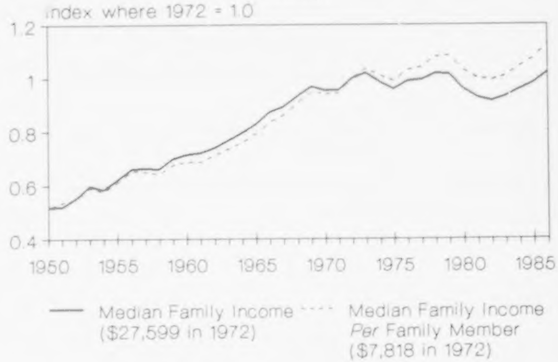
in absolute terms, the highest income group spends twice as much per family member for groceries as the lowest, and eight times more for meals at restaurants.[28] Wealthier families also devote more of their resources to clothing, education, and recreation, while lower income groups spend comparatively more on health care. Such differences reflect the fact that as incomes fall, basic expenditures must be maintained while such "luxuries" as new clothes and recreation are cut back.

Tracing spending patterns by income and income cohort is needed to understand how changes in national income may affect spending, and also to understand the fate of low income families who may be hurt by changes in income distribution. It is difficult, however, to disentangle the effects of social class and fashion on spending from the effects of income. Given the lack of data, a snapshot of spending in one year (cross-sectional data) must often be used to anticipate future changes over time—an admittedly perilous assumption for extrapolation. It is not obvious, for example, that if future economic growth gave middle class families purchasing power equivalent to that of wealthy households today, they would spend the income in the same way as today's rich.

Trends in Income and Income Distribution

The long upward trend in median family income per family member stopped in the late 1960s (see figure 2-5). While the income available for spending has remained roughly constant, there has been a striking change in the distribution of income among families since the mid 1970s. The average incomes of all but the wealthiest families fell between 1977 and 1984, while those of families in the very highest income groups increased sharply (see table 2-6). Indeed, only the wealthiest 10 percent of American families enjoyed any growth in average income between 1977 and 1984. In effect, the wealthiest 10 percent of U.S. families enjoyed all of the increase in economic output of this period. The U.S. Congressional Budget Office (CBO) forecast shown in table 2-6 anticipates real income growth for nearly all family groups between 1984 and 1988, though the rate of growth will be greatest within the wealthiest decile.[29]

Figure 2-5.-Changes in Family Income (in 1984$)



How To Read This Table: Median family income (half of all families earn more and half earn less than the "median" income) and median family income per family member (median income divided by the number of people in each family) both approximately doubled between 1950 to 1972, when growth stopped abruptly. In spite of growth in the 1980s, median income returned to 1972 levels only in 1986.

SOURCE: U.S. Bureau of the Census, Current Population Reports, Series P-60, No. 156, *Money Income of Households, Families, and Persons in the United States: 1985* (Washington, DC: U.S. Government Printing Office, 1986).

The sharp differences in rates of income growth mean that the wealthiest families are capturing a growing share of all income available for personal spending. The wealthiest 20 percent of all families now command 50 percent of U.S. after-tax family income. Assuming that this trend continues, half the work of anticipating how Americans will spend their money during the next few decades involves anticipating the spending habits of this wealthiest quintile. The share of all national income earned by the wealthiest 1 percent of all households increased 4 percentage points between 1977 and 1984 (see figure 2-6); the share of the wealthiest groups is expected to increase through 1988, even after accounting for the effects of 1986 tax reform.[30]

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[28] This study divides the 11 consumer household types introduced in the previous discussion into 7 income cohorts. The cohorts are selected by first ranking all consumer households by "income per consumer household member" (e.g., a family of four with a household income of $20,000 would have an "income per consumer household member" of $5,000); this ranked set is then divided into 7 groups consisting of equal numbers of consumer households. Expenditure categories are taken from the "Consumer Expenditure Survey," developed by the Bureau of Labor Statistics at the U.S. Department of Labor. See "Consumer Expenditure Demand Projection Program," ibid.

[29] U.S. Congressional Budget Office, *The Changing Distribution of Federal Taxes: 1975-1990* (Washington, DC: U.S. Government Printing Office, October 1987).

[30] U.S. Congressional Budget Office, ibid., p. 70.

Table 2-6.—Average Family Incomes Before and After Taxes[a] (000s of 1987 dollars)

Income cohort[b] (deciles)	Before taxes 1977	Before taxes 1984	Before taxes 1988	After taxes 1977	After taxes 1984	After taxes 1988
1	$ 4.1	$ 3.4	$ 3.5	$ 3.8	$ 3.0	$ 3.2
2	8.3	7.4	7.6	7.6	6.8	7.0
3	13	12	12	11	10	11
4	18	16	17	15	14	14
5	24	21	22	19	18	18
6	29	27	28	24	22	22
7	36	33	34	28	26	27
8	43	42	43	34	32	33
9	54	54	55	42	41	42
10	107	115	122	75	87	90
Top 5%	144	160	172	97	120	125
Top 1%	307	387	430	187	283	304
All families	$ 34	$ 33	$ 34	$ 26	$ 26	$ 26

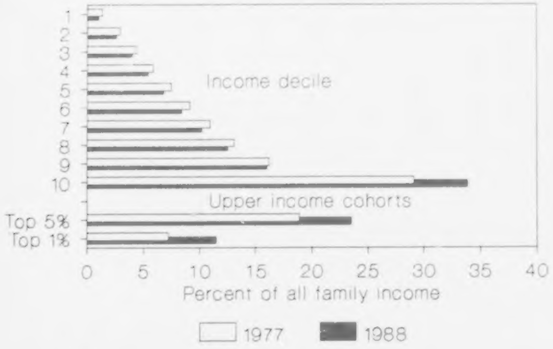
How To Read This Table: In 1977, the before-tax income of the 10% of all families with the lowest family income was $4,100 (1987 dollars), which fell to $3,400 (1987 dollars) in 1984. During the same period, the after-tax family income of the wealthiest 1% of all families increased from $187,000 to $283,000 (1987 dollars).

[a] The "before-tax income" includes the taxes paid by corporations. These taxes are assigned to households in proportion to their income from capital. This income is, of course, collected from companies, and never reaches the households to which it is allocated.

[b] The income cohorts are constructed by ranking all families in order of their total income (including the corporate tax "income" described in the previous note). The first decile is the 10 percent of families with the lowest incomes, etc.

SOURCE: Based on U.S. Congressional Budget Office, *The Changing Distribution of Federal Taxes: 1975-1990* (Washington, DC: U.S. Government Printing Office, October 1987).

Figure 2-6.-Distribution of Family Income After Taxes



How To Read This Table: In 1977, the average family in the 1% of families with the highest incomes received about 7% of all family income, while in 1988 these families are expected to receive 11% of all family income. On the other hand, there was no significant change in the share of income received by the families in the eighth income decile, which remained close to 10% of all family income. Families are placed in "deciles" as follows: all families are ranked by their total income; the bottom 10% are in the first decile, the next 10% are in the second decile, etc. (the incomes reported assume that corporate taxes are allocated to capital and not labor income).

SOURCE: U.S. Congress, Congressional Budget Office, "The Changing Distribution of Federal Taxes: 1975-1990," Washington, DC, October 1987.

Diverging paths of income growth represents a reversal of an earlier trend. Between 1950 and 1967, for example, the wealthiest 20 percent of American families actually lost their share of total U.S. personal income, dropping from 42.7 to 40.4 percent, while the shares of all other income groups—particularly those of the lowest 40 percent—increased. Since that time, the trend has been toward increased share among the upper income groups and a decline elsewhere; the pace of this movement doubled during the 1979-84 period.[31]

Changes in the distribution of family incomes depend on changes in several different areas (discussed below):[32]

- the distribution of individual wage and salary earnings,

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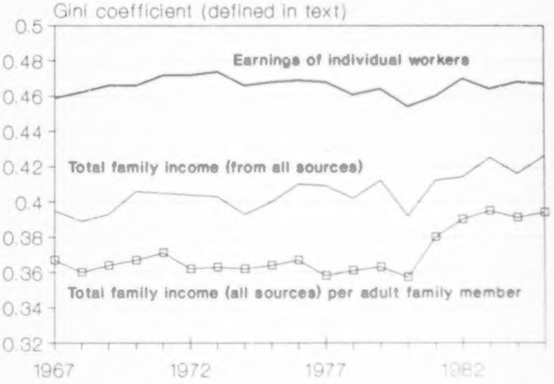
[31] Richard S. Belous, Linda H. LeGrande, and Brian W. Cashell, "Middle Class Erosion and Growing Income Inequality: Fact or Fiction?" U.S. Congressional Research Service, Library of Congress Report No. 85-203 E, Nov. 28, 1985. Trends in income distribution between 1979 and 1984 must be treated with caution since they represent different points in the business cycle. See also the discussion on page 376.

[32] All of these factors are discussed at greater length in ch. 11.

- the number of wage earners in each family (a family may have a high income by combining a number of low wages),
- the distribution of capital earnings, and
- the distribution of transfer payments and other earnings.

While a considerable amount of work has been and is being done to disentangle these factors, much remains unknown.[33] Given available data, it appears that growing inequality of family incomes is driven primarily by shifting demographics and inequality in capital income, rather than by inequality in wage and salary earnings of workers (see figure 2-7).[34] The "Gini" coefficient that measures wage inequality indicates little change since 1967, while inequality in family income (which includes capital income) has increased sharply since 1980.[35]

Figure 2-7.-Income Distribution from Three Different Perspectives



How To Read This Table: Inequality in yearly wage and salary earnings of individual workers remained roughly unchanged between 1967 and 1985, while total family income (from wages and all other sources) per adult became less equal starting in the late 1970s. In this figure children are counted as a fraction of an "adult equivalent" in computing per adult income. The measure of inequality used is the "gini coefficient" in which 1 indicates extreme inequality and 0 exact equality. See Blackburn and Bloom for definitions.

SOURCE: McKinley L. Blackburn and David E. Bloom, "The Effects of Technological Change on Earnings and Income Inequality in the United States," National Bureau of Economic Research, working paper No. 2337, Cambridge, MA, August 1987.

These findings are based on data from the U.S. Bureau of the Census that brings with it a limitation in analysis of income distribution: the actual income of the wealthiest families is not reported. Wealthy families report only that their incomes are above some threshold level, or "top code"—a level that has increased at irregular intervals over the last decade. Since much income growth has occurred in the wealthiest families, it is obvious that the Census data introduces some distortion.

Using data which avoids the "threshold" difficulty, the CBO analysis discussed above suggests that between 1977 and 1984, the Gini coefficients for after-tax income increased from 0.42 to 0.47; before taxes, the coefficients were 0.45 in 1977 and 0.48 in 1984.[36]

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[33] Numerous studies argue that the distribution of American income is becoming less equal, propelled by the arguments made in Barry Bluestone and Bennett Harrison, *The Deindustrialization of America* (New York, NY: Basic Books, 1982). Recent discussions include, among others, Lester C. Thurow, "A Surge in Inequality," *Scientific American*, vol. 256, No. 5, May 1987, pp. 30-37; Gary Burtless, "Inequality in America: Where Do We Stand?" *The Brookings Review*, summer 1987, pp. 9-16; Kathryn L. Bradbury, "The Shrinking Middle Class," *New England Economic Review*, Federal Reserve Bank of Boston, September/October 1986; and J. Rose, *The American Profile Poster* (New York, NY: Pantheon Books, 1986).

Others argue that such conclusions should not be drawn so quickly. Neal H. Rosenthal, in "The Shrinking Middle Class: Myth or Reality?" *Monthly Labor Review*, March 1985, pp. 3-10, indicated that trends in weekly wage and earnings (as distinct from income) measured by occupation point to movement away from both lower and middle wage groups and into the upper third. Other studies finding that income distribution is not growing less equal include Marvin H. Kosters and Murray Ross, "Deficits, Taxes, and Economic Adjustments," in American Enterprise Institute, *Contemporary Economic Problems*, Philip Cagan (ed.), Washington, DC, 1987; Sar. A. Levitan and Peter E. Carlson, "Middle Class Shrinkage?" *Across the Board*, October 1984, pp. 55-59; and Robert J. Samuelson, "Middle-Class Media Myth," *National Journal*, Dec. 31, 1983, pp. 2673-2678.

Attempts have been made to reconcile these conflicting views. Robert Z. Lawrence, in "Sectoral Shifts and the Size of the Middle Class," *The Brookings Review*, fall 1984, pp. 3-11, argued that growing unequal distribution of income between 1969 and 1983 was real, but was due to the demographic effects of young baby boomers entering the work force and not to the wage effects of an employment shift to lower paying industries. Patrick J. McMahon and John H. Tschetter, in "The Declining Middle Class: A Further Analysis," *Monthly Labor Review*, September 1986, pp. 22-27, found that while the proportion of all jobs in high-wage occupations (again, as distinct from income) increased during the 1973-82 period, the earnings distribution within those occupations grew somewhat poorer.

For more on this subject, see U.S. Congressional Research Service, "Middle Class Decline? Bibliography-in-Brief, 1983-1986," No. 87-68 L, Washington, DC, January 1987.

[34] McKinley L. Blackburn and David E. Bloom, "The Effects of Technological Change on Earnings and Income Inequality in the United States," National Bureau of Economic Research, working paper No. 2337, Cambridge, MA, August 1987.

[35] The Gini coefficient measures inequality. A coefficient of 0 means perfect equality, a coefficient of 1 would mean that all earnings or income is received by one family.

[36] U.S. Congressional Budget Office, op. cit., footnote 29. The pre-tax Gini coefficients assume that corporate income tax is allocated to capital earnings.

The inclusion of the income of wealthier families leads to a coefficient considerably higher than those shown in figure 2-7.

Wage and Salary Earnings of Individuals.—Technical change, shifts in industry structure, changing trade patterns, changing management strategies, an increase in part-time work, and a variety of other factors all play a role in determining individual wage and salary earnings; the issue is examined more thoroughly in chapter 11. In brief, there appears to be no net change in the earnings of individuals (see the top line in figure 2-7). This results in part because the convergence of male and female wages has removed a major source of inequality.[37]

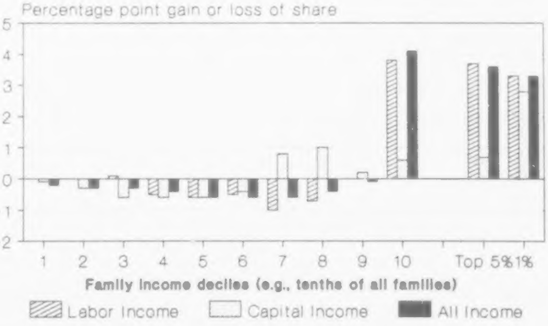
The CBO data, which include the distribution of wages and salaries among high-income groups, indicates that high-income families are increasing their total share of all wage income as well as their share of total income. The wealthiest 10 percent of families increased their share of all labor income from 29 percent in 1977 to 32 percent in 1984.[38] Unfortunately, it is impossible to use the data to separate differences in labor earnings per family from differences in earnings by each family member.

Family Composition.—Changes in the composition of families have had a major effect on the distribution of family income. Families with only one earner, particularly those headed by women with children, have significantly lower incomes than those with multiple earners.[39] This alone contributes to family income inequality. Indeed, the shrinking size of households has produced a decline in the number of earners per household in recent years. The average household had 1.16 earners in 1979, but only 0.94 earners in 1984.[40] Inequality is further increased by a strong correlation between the wages earned by individuals in the same family. A man earning the minimum wage is most likely to be married to a person earning the minimum wage, while virtually no men earning more than $75,000 in 1984 were married to working women making less than $10,000 a year.[41]

Taken together, demographic factors had the effect of increasing inequality in family income since 1980, even while there was no greater inequality in the earnings of individuals (the middle line in figure 2-7). When family income is expressed as income per family member, inequality has grown even more rapidly (the bottom line in figure 2-7).

Capital Income.—Income from capital sources is distributed much less equally than income from labor. Not only is capital (or "unearned") income becoming a larger share of all family income, but the way this income is allocated among families is becoming less equal (see figure 2-8). In 1984, the wealthiest 10 percent of all families had 63 percent of all income from capital, and the wealthiest 1 percent of families had 37 percent.[42] Similarly, ranked by net worth, the bottom 26 percent of American households owned only 10 percent of total net worth in 1984, while the top 12 percent of households owned 38 percent of total net worth.[43]

Figure 2-8.-Change in the Share of Family Income: 1977 to 1988 (change in percentage share of all personal income)



How To Read This Table: The share of all income earned by families in the 10th income decile increased over 4 percentage points between 1977 and 1988. The share of families in the 6th income decile fell by about ½ of a percentage point. The incomes reported assume that corporate taxes are allocated to capital and not labor income.

SOURCE: U.S. Congress, Congressional Budget Office, "The Changing Distribution of Federal Taxes: 1975-1990," Washington, DC, October 1987.

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[37] M. Blackburn and D. Bloom, op. cit., footnote 34.

[38] U.S. Congressional Budget Office, op. cit., footnote 29, p. 65.

[39] H. Hayghe, "Two-Income Families," *American Demographics*, September 1981, pp. 35-37.

[40] U.S. Department of Commerce, Bureau of the Census, "Current Population Survey," various years.

[41] Lester C. Thurow, "The New American Family," *Technology Review*, August/September 1987, p. 27.

[42] U.S. Congressional Budget Office, op. cit., footnote 29.

[43] U.S. Department of Commerce, Bureau of the Census, "Household Wealth and Asset Ownership: 1984," Current Population Reports, Household Economic Studies, series P-70, No. 7.

The Influence of Income Distribution on National Spending

The impact that changing income distribution could have on expenditures is shown in table 2-7. Two alternatives are explored: one, called the "middle" case, in which it is assumed that in 2005 all consumer households are in the middle income cohort; and another, the "extremes" case, in which consumer households are divided equally between the two highest and two lowest income cohorts, with none in the middle.[44]

The results suggest that if equality in income distribution is increased, more would be spent on food, housing (mostly home maintenance), transportation (mostly auto-related), and recreation (goods). Less would be spent on clothing and personal care (with the exception of non-apparel services like health clubs and beauty parlors) and personal business (other than phone use). Of the amenities listed here, only spending on personal business would change significantly.

If there were less equality—the extreme case—proportionally more would be spent on clothing and personal care and recreation (mostly services), and less on transportation (especially new cars, though air fares would also grow). There would be little difference among the other amenity categories, though increased spending on household maintenance services and appliances would be offset by

Table 2-7.—The Potential Impact of Changing Income Distribution on Personal Consumer Expenditures in the Year 2005 (assuming 3 percent annual economic growth, no change indexed to 100.0)

	Change in spending on selected amenities or items	
Amenity or item purchased[a]	Middle[b]	Extremes[c]
Food	104.0	98.7
Food and beverages at home	105.4	98.7
Food and beverages away from home	102.3	98.6
Tobacco	98.5	99.1
Housing	101.9	100.9
Owner occupied	104.2	93.2
Renters	87.3	106.3
Maintenance services	112.7	154.8
Maintenance commodities	111.8	86.6
Tenants' insurance	105.0	99.8
House furnishings	107.9	98.4
House appliances	97.0	132.8
Water and sewer	101.3	112.6
Transportation	104.1	90.0
New vehicles	103.8	73.8
Used vehicles	113.1	90.7
Vehicle maintenance	110.6	96.7
Other private transportation	113.0	89.3
Air fare	91.3	108.5
Other public transportation	84.7	95.8
Clothing and Personal Care	94.2	106.9
Personal care commodities	92.9	109.8
Personal care services	113.5	107.2
Men's and boys' clothing	86.8	105.8
Women's and girls' clothing	98.4	105.1
Other (including jewelry)	82.9	106.1
Footwear	94.2	114.1
Apparel services	93.7	108.9
Personal Business and Communication	83.8	100.4
Telephone	103.7	100.3
Personal business	77.5	100.4
Recreation and Leisure	104.0	103.2
Entertainment services	91.9	120.3
Entertainment commodities	117.3	88.9
TV and sound	110.7	105.1
Lodging	98.0	96.6

How To Read This Table: Assuming 3 percent annual economic growth through 2005, in an economy where all households earned an income in the "middle" cohort (#4 of 7, where 7 cohort ranges are divided into equal numbers of households), the spending index for food would be 104.0—in other words, Americans would purchase 4 percent more food than would be the case with no change in income distribution. If all households were divided between the two lowest and two highest cohorts ("extremes"), the spending index on food would be 98.7, or 1.3 percent less than the "no change" scenario.

[a] The totals for PCE on amenity groups include certain items which have not been listed separately because the 2005 scenarios assume that expenditures on them would remain constant even with changing income distribution. See the appendix for details.

[b] Assumes all households in the middle income cohort (#4 of 7).

[c] Assumes households evenly distributed between two low and two high income cohorts (#1, 2, 6, 7, of 7).

SOURCE: U.S. Congress, Office of Technology Assessment, "Consumer Expenditure Demand Projection Program," April 1986, based on data provided by the U.S. Department of Labor, Bureau of Labor Statistics; the U.S. Department of Commerce, Bureaus of Census and of Economic Analysis; and the U.S. Department of Health and Human Services, Social Security Administration.

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[44] Of the 7 income cohorts introduced earlier in this chapter, selected by ranking all consumer households by "income per consumer household member" and dividing the ranked set into 7 heptiles consisting of equal numbers of consumer households, the fourth heptile is the "middle." Expenditure categories are taken from the "Consumer Expenditure Survey," developed by the Bureau of Labor Statistics at the U.S. Department of Labor. See "Consumer Expenditure Demand Projection Program," op. cit., footnote 27.

declines in maintenance commodities and new homes.

Comparing the middle case with the extremes, an economy consisting entirely of middle income consumer households would spend more on home purchasing, food (particularly food at restaurants), vehicles, and entertainment commodities. Households would also enjoy more of their entertainment at home.

Prices

The response of consumers to changes in price has received considerable theoretical attention, but applications of the theory are often frustrated by the scarcity of data. Complex interactive relationships (cross elasticities) make the problem difficult—consumption of beef may decline even when beef prices remain constant if chicken prices fall. Looking to the future, price effects pose an even greater dilemma, due to both the great difficulty of forecasting relative prices and the need to consider such issues as: will spending for travel decline if the price of communications falls?

In practical terms, these issues can only be handled by examining particular amenity networks in detail—a task undertaken in chapter 3. For present purposes, however, it is useful to have a feeling for the influence that a continuation of recent price trends might have on spending patterns. A complete set of recent price elasticities, constructed in a way that accounts for demographic effects, provides the basis of this analysis (again see the appendix).[45]

Demographics, Income, and Price: The Combined Effect

The possible effects of changes in household structure, income, and prices on household expenditure are shown in table 2-8. The table shows *relative* changes, not absolute ones. Overall, Americans would spend more on two-thirds of the items identified.

The figures assume annual 3 percent growth in GNP over the next 20 years, and that future household spending patterns can be estimated from current ones. Because incomes would increase rapidly in a high-growth economy, most of the changes presented in the table are caused by income effects rather than demographic ones (changes in population and household structure). If economic growth were slower, demographic effects would become more important.

The biggest change in share of spending comes in the food amenity, which loses 5.26 percentage points as a share of national spending. Most of this results from declines in grocery eating; eating out holds a virtually constant share. Under the assumptions of these calculations, spending on recreation would capture a growing fraction of all consumer spending because of both price and income effects.

Changes in household types would result in some increase in housing expenditures, but the overall effect would be more than compensated for by changes in income. Income increases would also lead to sharp growth in demand for restaurant eating, air travel, clothing, personal business, and entertainment services, while Americans would spend proportionally less on apartment rentals, smoking, and time spent on the telephone.

ALTERNATIVES FOR THE FUTURE

Constructing Scenarios

The remainder of this chapter describes alternative hypotheses about the ways consumers might spend their money (and instruct their governments to spend money in their name) in 2005. One such hypothesis is that things will continue much as they are now, and that the statistics already compiled on households, income, and prices can simply be extrapolated into the future—the "Trend" scenarios (see the appendix). Under these assumptions, spending for 2005 can account for an aging population by assuming that the aging baby boomers in a given income class will spend money in the same way as similar groups spend money today. There is, however, a qualification: the older baby boomers will

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[45] P. Devine, "Forecasting Personal Consumption Expenditures From Cross-Section and Time-Series Data," Ph.D. Dissertation, University of Maryland, 1983.

Table 2-8.—The Effects of Demographic Change, Income Growth, and Price Change on U.S. Personal Consumption in 2005 (changes in percent of all spending)

	Percent change from 1983 due to various factors				
Amenity or item purchased	All	Demographic	Income	Price	Interactive
Food	−5.26	0.07	−3.37	−1.87	−0.10
Food and beverages at home	−4.41	0.04	−4.05	−0.45	0.06
Food and beverages away from home	−0.15	0.03	1.31	−1.30	−0.19
Tobacco	−0.70	0.00	−0.63	−0.11	0.04
Housing	−0.48	0.40	−1.91	1.72	0.11
Owner occupied	0.28	0.19	0.00	0.47	0.00
Renters	−1.91	0.32	−1.81	0.19	0.03
Maintenance services	0.01	0.01	0.10	−0.07	−0.01
Maintenance commodities	−0.49	0.02	−0.30	−0.24	0.03
Tenants insurance	−0.02	0.04	0.02	−0.09	0.01
House furnishings	0.95	0.03	0.06	0.84	0.02
House appliances	0.71	0.01	0.17	0.47	0.06
Water and sewer	−0.01	0.01	−0.15	0.16	−0.03
Transportation	−0.51	0.06	0.38	−0.96	0.02
New vehicles	−0.33	0.03	−0.00	−0.33	−0.02
Used vehicles	−0.24	0.01	0.05	−0.29	0.01
Vehicle maintenance	−0.13	0.04	−0.06	−0.14	0.04
Other private transportation	−0.02	0.00	−0.01	−0.01	0.00
Air fare	0.37	0.00	0.37	−0.01	−0.00
Other public transportation	−0.17	0.00	0.02	−0.18	−0.00
Clothing and Personal Care	1.84	0.10	1.63	0.01	0.10
Personal care commodities	0.06	0.00	0.06	−0.00	0.00
Personal care services	0.11	0.01	−0.02	0.11	0.01
Men's and boys' clothing	0.39	0.02	0.38	−0.02	0.01
Women's and girls' clothing	0.94	0.06	0.87	−0.05	0.05
Other (including jewelry)	0.24	0.01	0.25	−0.01	0.01
Footwear	0.03	0.01	0.02	−0.01	0.01
Apparel services	0.06	0.00	0.06	−0.00	0.00
Personal Business and Communication	0.95	0.07	1.26	−0.16	−0.23
Telephone	0.17	0.02	−0.35	0.61	−0.08
Personal business	0.78	0.09	1.61	−0.77	−0.15
Recreation and Leisure	3.47	0.10	2.02	1.26	0.09
Entertainment services	1.26	0.06	1.43	−0.21	−0.02
Entertainment commodities	0.89	0.02	0.20	0.64	0.03
TV and sound	0.83	0.00	0.11	0.68	0.03
Lodging	0.49	0.02	0.28	0.14	0.06

How To Read This Table: Assuming 3 percent annual economic growth through 2005, 2005 household distribution, and prices and incomes adjusted to this growth, the percentage of American spending on food eaten at home (as a share of the items listed here—roughly three-quarters of all personal spending) would decline by 4.41 percentage points. Changing incomes would account for a drop of 4.05 points and changing prices would account for a 0.45 point drop, while demographic changes would exert a slight positive trend of 0.04 percentage points; the effect of interaction between these factors would be a rise of 0.06.

NOTES: This table estimates how U.S. consumer spending on selected items and amenities could change, and attempts to isolate what factors may contribute to that change. The "All' column assumes 3% annual economic growth through 2005, 2005 household structure as developed earlier in this chapter, and a set of possible price changes for these items in 2005 as outlined in the appendix. Incomes are then raised by 35.5%, the level at which Americans will have enough purchasing power to satisfy the estimate of personal spending in 2005 (also developed in the appendix).

For individual components of change:
- For demographic changes in 2005: see table 2-4; price and income held at 1983 levels.
- For income changes in 2005: incomes raised by 35.5 percent; demographics and prices held at 1983 levels.
- For price changes in 2005: see the appendix; demographics and income held at 1983 levels.

The effects of these three components that cannot be traced individually but are rather the result of a combination of factors are captured in the "Interactive"column.

SOURCE: U.S. Congress, Office of Technology Assessment, "Consumer Expenditure Demand Projection Program," April 1986, based on data provided by the U.S. Department of Labor, Bureau of Labor Statistics; the U.S. Department of Commerce, Bureaus of Census and of Economic Analysis; and the U.S. Department of Health and Human Services, Social Security Administration.

have had life-histories significantly different from older Americans today. They will be better educated and healthier, and will have a far higher share of women retired from work than is currently the case. It is extremely difficult to predict whether this effect will result in new spending patterns.[46] Similarly, America's ethnic composition will change. Between now and 2000, roughly one-half of the increase in the U.S. population will be from minority ethnic groups.[47] These developments pose problems for analyzing future spending patterns, because it is nearly impossible to allow for the effects of changing ethnic composition.

For these and many other reasons already discussed, trends can be misleading during periods of fundamental change. The new environment in which the economy operates allows for a number of major shifts in the way households elect to achieve amenity through private and public choice. Given the wide array of possible choices, and the enormous range of uncertainties about the cost and capability of emerging technology, there is no completely satisfactory method for outlining the possibilities, nor any mathematical technique for producing them.

Potential changes are represented though an illustrative set of "Alternative" scenarios, which will be developed further in chapter 3. These scenarios were designed with the help of individuals familiar with the operation of the eight major amenity categories (Food, Health, Education, etc.), who were charged with describing a way that new technology *could* lead to a significant increase in productivity during the next 20 years given appropriate changes in regulation, information flows, and other factors. Along with the Trend scenarios, the Alternatives share common assumptions about such factors as population growth, rates of consumer household formation, and rates of income and GNP growth (see box 2-B and the appendix for details).

Given these scenarios, two patterns of national income growth are examined: a pessimistic assumption, represented by 1.5 percent annual growth in GNP (as in the late 1970s and early 1980s); and an optimistic assumption, represented by 3 percent per year GNP growth. This range is plainly not meant to be a forecast, but rather is designed to bracket a wide yet reasonable range of possibilities.

In principle, it is possible to develop a closed, internally consistent model that can accommodate these connections. It proves extremely difficult to use such models in practice when exploring the possibility of significant changes in technology or in private and public management during a period of 20 years. While the analysis presented throughout this work is consistent in that the income generated by output is equal to the money spent on final and intermediate products, it is not based on a closed model of the economy.[48]

Summarizing the Results

The scenarios are summarized in table 2-9; chapter 3 and the appendix provide further detail. The proportion of expenditure on Food goes down no matter what growth rate or assumption about technology is used—as does, to a lesser extent, that spent on Transportation. On the other hand, more is spent on Recreation and Leisure in all cases, and both Clothing and Personal Care (mostly clothing) and Personal Business and Communication gain in all but the 1.5 percent Trend scenario (in which they hold the same share as 1983).

Considering first the 3 percent scenarios, Food purchases are expected to decline as a fraction of all spending, though more slowly than in the past largely because of an increase in the proportion of more expensive food eaten away from home. The Trend and Alternative scenarios differ considerably in estimates of future Health spending. The Trend assessment shows spending for Health reaching 14 percent of the total in 2005 while the Alternative scenario suggests 11 percent, due to greater reliance on preventative (as opposed to curative) techniques.

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[46] William Lazer and Eric H. Shaw, "How Older Americans Spend Their Money," *American Demographics*, September 1987, p. 41.

[47] U.S. Bureau of the Census, *Statistical Abstract of the United States: 1987* (107th ed.), Washington, DC, 1986. Changing ethnic composition, of course, has occurred for some time; the U.S. Bureau of the Census has recently reported that the U.S. Hispanic population has increased by 30 percent since 1980, as opposed to a 6-percent increase in the non-Hispanic population. See U.S. Bureau of the Census, "The Hispanic Population in the United States: March 1986 and 1987," Current Population Reports, Series P-20, No. 416, Washington, DC, August 1987.

[48] Consistent sets of forecasts were developed by beginning with rough estimates of structural change in production and productivity, using the resulting GNP growth to estimate purchasing, and then using this purchasing to estimate production and GNP. The estimates are combined explicitly in ch. 13.

Box 2-B.—Basic Strategies in Developing Scenarios

1. *Demographics*

Population was forecast using a version of the projection model used by the U.S. Social Security Adminstration,[1] modified for use on a personal computer.[2] The projection includes an allowance for illegal immigration somewhat higher than that used by the U.S. Bureau of Census' "middle series."[3] For more detail, see the appendix.

Estimates of the number of people in each age group can be converted to estimates of household types given assumptions about future marriage and divorce rates. Annual marriage rates have remained within ranges of 9.9 to 10.9 per thousand since 1968, and of 10.2 to 10.6 since 1978. Annual divorce rates, after rising consistently between 1960 and 1979, have since remained fairly constant at around 5.0 per thousand. The hypothesis used here is that these recent steady rates will continue into the foreseeable future. Assuming that the likelihood that a person of a given age and sex becomes a member of any one type of household is the same in the year 2005 as it was in 1984, the number and type of future households can then be calculated (see table 2-4).[4]

2. *GNP Growth*

Two rates of gross national product (GNP) growth are considered, one based on the optimistic assumption that rates of productivity growth characterizing the years 1965 to 1975 can be recovered, and one based on the assumption that productivity would grow at the much slower 1975 to 1985 rates. Together with assumptions about size of the work force and other factors (discussed in more detail in ch. 13), these result in GNP growth rates of approximately 1.5 and 3 percent per year.

3. *Allocating GNP to Consumption*

All the cases considered in this analysis share the assumption that the sum of personal consumption and government spending will remain at a constant share of 85 percent of GNP. This ratio has not varied by more than 3 percentage points for nearly 30 years. Personal consumption expenses have fluctuated in recent years from a low of 61.5 percent of GNP in 1973 to a high of 65.5 percent in 1983, and have since remained around 65 percent. The analysis also assumes that defense will maintain its present 7 percent share of GNP.[5]

5. *Prices*

Relative prices are assumed to change at roughly the rate of the past two decades, with exceptions based on changes in trade and production technology discussed in the appendix. The set is made consistent in the sense that a shift to the new price set would not change total spending.

6. *Allocating Consumption by Product Type*

With the exceptions discussed in the text, money available for consumption is assumed to be allocated given estimates of price, income, and household size using the methods described to produce table 2-9. The calculations are based on an analysis of spending by income cohort and household type.[6] They are *not* based on an assumption that spending rises or falls exponentially with income, but allow for more complex relationships. For example, spending on used cars first rises and then falls as incomes increase.[7]

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[1] The assumptions on life expectancy and fertility used here have been selected from the ranges developed by the Social Security Administration (SSA); see U.S. Department of Health and Human Services, Social Security Administration, "Social Security Area Population Projections, 1984," Actuarial Study No. 92, Washington, DC, May 1984.

[2] "Modified Social Security Population Projection Program," working paper prepared for the Office of Technology Assessment, November 1985.

[3] Frank D. Bean, et al., "Projections of Net Legal and Illegal Immigration to the United States," contract paper prepared for the Office of Technology Assessment by the Population Research Center, University of Texas, Austin, TX, August 1984.

[4] The model from which these results were obtained used the Current Population Survey for 1984, and weights assigned to individuals of each age and sex cohort for each of 17 household types. See "Household Formation Program," working paper prepared for the Office of Technology Assessment, Washington, DC, May 1986. The 17 household types were then aggregated into the 11 categories presented in tables 2-4 and 2-5.

[5] As a fraction of GNP, Federal defense spending has followed a down-and-up curve over the past 25 years—falling steadily (with the exception of the Viet Nam War years of 1965 to 1968) from 9.7 percent in 1960 to 4.9 percent in 1979, only to rise rapidly through 1983 to a level of nearly 7 percent, where it has remained since. This analysis therefore assumes that a 7 percent average, which is both close to the present figure and the approximate mid-point in the historical trend, will hold over the next two decades. For an annual series of defense spending as a fraction of GNP, see U.S. Bureau of the Census, *Statistical Abstract of the United States: 1986* (106th ed.), Washington, DC, 1985, table 540.

[6] See "Consumer Expenditure Demand Projection Program," working paper prepared for the Office of Technology Assessment, April 1986.

[7] The equation linking spending to income is quadratic.

Table 2-9.—Spending on the Amenities: 1983 and the Scenarios
(In percent of personal and total spending in 1983 dollars)

			year 2005							
	1983		Trend 3%		Trend 1.5%		ALT 3%		ALT 1.5%	
	PCE	Total	PCE	Total	PCE	Total	PCE	Total	PCE	Total
Food	20%	16%	16%	13%	19%	15%	16%	12%	16%	13%
Housing	26	20	25	19	27	21	23	18	23	18
Transportation	13	12	11	10	11	11	10	10	11	11
Health	12	11	15	14	14	13	12	11	13	13
Clothing and Personal Care	9	7	11	8	9	7	12	9	11	8
Education	2	7	1	5	1	6	1	6	2	7
Personal Business and Communication	8	6	9	7	8	6	11	8	10	7
Recreation and Leisure	10	8	13	10	11	9	15	12	14	11
Defense	0	7	0	7	0	7	0	7	0	7
Other Government Expenditure	0	5	0	7	0	6	0	6	0	4
Total (percent)	100	100	100	100	100	100	100	100	100	100
($1983 billion)	2,229	2,905	4,270	5,565	3,093	4,031	4,270	5,565	3,093	4,031

NOTE: Total includes all government purchases of goods and services. ALT = Alternatives (see text for definitions). Totals may not add to 100 due to rounding.

SOURCE: 1983 statistics from U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, table 2.4; Trend projections drawn from U.S. Congress, Office of Technology Assessment, "Consumer Expenditure Demand Projection Program," April 1986, based on data provided in the "Consumer Expenditure Survey," U.S. Department of Labor, Bureau of Labor Statistics (see the appendix for details); Alternatives from the Office of Technology Assessment.

The share of Housing also differs between the two 3 percent scenarios, being 1 percent lower in the Alternative than in the Trend. This is due to the assumed sharp fall in the cost of household energy utilities, and to an assumption that real shelter costs can be kept at 1970 levels using technical improvements in the production and operation of homes.

The shares of income spent for Personal Business and Communication, Recreation and Leisure, and Clothing and Personal Care are all higher in the Alternative scenario. In the case of Personal Business and Communication, the difference is created by greater use of both the telephone and services outside the house. Similarly, the Alternative assumes that technology allows for an expansion of recreational telephone use, and of the information, educational, and entertainment resources available in the home through television and computers. The Alternative case also envisions a 15 percent drop in the real price of clothing, which boosts spending considerably. Overall, as might be expected, the 3 percent Alternative case differs most from 1983 in terms of distribution of personal spending, since high economic growth is combined with liberal assumptions about the impact of technology on purchasing patterns.

In the low growth (1.5 percent) scenarios, the Trend patterns are quite similar to those of 1983. Food expenditures are lower in the Alternative case than in the Trend, despite generous assumptions about family diet. The share of Housing falls even more sharply in the Alternative, largely due to the reasons given for the 3 percent cases. On the other hand, expenditures on Recreation and Leisure are distinctly higher in the Alternative, in which new technologies allow for an expansion of entertainment products and services at lower prices—making a wide range of entertainment resources available to all. Government spending as a whole (counting all public expenditures on the amenities) increases somewhat more rapidly in the Alternative case than the Trend, primarily because of assumed increases in spending on education.

The statistics just discussed do not directly address some of the most critical questions. What, for example, will happen to the real quality of housing, to the flexibility and convenience of transportation, or to the state of American health in these scenarios? To what extent will future changes in consumer demand bring real improvements in amenity to the lives of Americans? Such questions cannot be answered with precision. To the extent that it is possible to talk in terms of quality as well as quantity, the discussion of changes in amenity will be approached on a sector-by-sector basis in chapter 3. If nothing else, a patient insistence that economic progress be clearly linked to an improvement in amenity provides a focus for the abstract calculus of productivity and technology that is the subject of much of this report.

Chapter 3

Eight Amenity Groups

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Chapter 3

Eight Amenity Groups

This chapter examines characteristics of eight major household amenity groups and explores options for the next two decades. It does not cover national defense or government activities not directly associated with a household amenity. The discussions form a diverse set but are all designed around the following plan. They begin with a description of the way amenity might be measured—a description of the units that might be used to gauge progress even if measurement is difficult because of the absence of good data. Second, they show how themes raised in the previous chapter apply in each amenity group. The themes include trade-offs between time, consumer spending, and government spending; growth in specialized markets; and changes in regulations that affect consumer purchasing. They end with a brief description of hypothetical patterns of future spending. These descriptions are used later in this volume to explore the potential impact of future consumption patterns on economic structure and on jobs.[1]

FOOD

There are two criteria against which to measure changes in the price, quality, information, and other factors that influence a nation's diet:

1. do the changes improve the quality, variety, and convenience of the food purchased and
2. has the new diet improved health?

Growth in choice available to most American households does not necessarily translate into a diet more likely to promote health. Indeed, higher incomes may lead to diets that are less healthy if consumption of fats and alcohol increases while consumption of bulk fiber declines.[2] An unhealthy diet may be purchased as a result of an informed decision to ignore the advice of physicians, ignorance of established links between diet and health (or lack of information about product contents), or the absence of credible information linking diet and health. The relative role of these factors, and therefore the influence of programs designed to facilitate consumer choice, remains ambiguous. These issues are also relevant in the section on spending for health that follows.

Quality and Variety

While people still go hungry in the United States, the quality and variety of the food eaten by most Americans have improved considerably. Many foods have become cheaper, production and packaging technologies have improved, the health implications of different diets are more widely understood, increased trade has brought a wider variety of foods to the U.S. consumer, and more meals are eaten outside the home, partly because more women are in the work force.

Net Food Purchases

The total quantity of food purchased per person increased by only 5.5 percent between 1965 and 1985 (largely the result of demographic factors), but food quality and diversity appears to have increased substantially. A variety of large and small grocery stores have emerged. The typical new supermarket may sell 15,000 to 20,000 separate products, and large stores may sell many more types.

Red meat consumption per capita peaked in the mid-1970s (red meat prices increased substantially during the late 1970s as lucrative grain exports increased feed prices), but per capita consumption of fish and poultry increased 34 and 69 percent respectively between 1965 and 1985.[3] During the same two decades, per capita purchases of fresh fruits increased 12 percent, with declines in staples such as oranges and grapefruit offset by large increases in demand for more exotic fruits; per capita consumption of fresh vegetables grew 30 percent while that of frozen vegetables grew 50 percent. Increased variety in American cooking is measured in part by the near doubling in per capita consumption of spices over the period. There was also a 30-percent increase in per capita consumption of sugars and other sweeteners.

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[1] A reader interested in tracing the performance of a specific amenity network from consumption recipe to job generation can read appropriate sections from chs. 3,6,9 and 12.

[2] L.A. Cohen, "Diet and Cancer," *Scientific American*, vol. 257, No. 5, November 1987, pp. 42-48.

[3] K.L. Bunch, "Food Consumption, Prices and Expenditures" U.S. Department of Agriculture, Economic Research Service, Statistical Bulletin 749, Washington, DC, January 1987.

A survey by the U.S. Department of Agriculture (USDA) in 1978 showed that the average respondent ate 25 to 28 different types of food over a 3-day period, although the range was from 4 to 63 unique food items.[4] Total consumption varied greatly with age and sex; males older than 23 appear to eat more than the average number of foods, and females aged 15 to 22 consume less than the average.[5]

Eating Away From Home

A system for tracking food expenditures developed by USDA suggests that by 1983, some 40.9 percent of all money spent on food was eaten away from home.[6] Only about 20 percent of the quantity of food and beverages consumed are eaten away from home; 3.7 out of 21 meals are eaten away from home.[7] By the turn of the century, the average American may spend half of every food dollar away from home.

The choice of eating place depends heavily on household type and income (see table 3-1). The addition of a family member over the age of 65 typically increases household spending in cafeterias by 9 percent. The addition of a child of age 12 or younger reduces overall spending in all food service establishments by 7 percent, but increases spending in fast food restaurants by 26 percent and in take-out restaurants by 16 percent.[8] Single-person households, whether young or old, spend a large share of their food budget away from home—typically 45 percent.[9] Families with working wives spend 28 percent more on food away from home than comparable families with housewives, although the increase drops to 7 percent after controlling for income;[10] most of the rise goes to specialty restaurants. In contrast, elderly households spend more in cafeterias and less in specialty restaurants.

It is apparent that the food purchased in fast food restaurants has become more diverse. In addition to the traditional hamburgers, french fries, soft drinks, sweets, and pizza, fast food now embraces seafood, chicken, sandwiches, breakfast items, baked potatoes, and salad. The number of cuisines available as fast food has also increased, and now includes Mexican, Chinese, Indian, and other types. However, since fast food outlets have often expanded their markets at the expense of family-run restaurants, often serving regional menus, it is not obvious that real diversity has increased.[11]

Growth in other segments of the food service sector, particularly in more expensive restaurants, has introduced many Americans to varied cuisines. The "upgrading" of food purchasing patterns—resulting in higher prices per amount of food consumed—has been expressed most recently in the growth of the "up-market hamburger restaurants," which not only offer a more diverse and expensive menu but also sell alcohol. Traditional restaurants still claimed 51 percent of all sales in "separate eating places" in 1982, but fast food was a close second with 44 percent.[12] Of franchised restaurants, 42 percent serve hamburgers, 17.5 percent pizza, 12.4 percent chicken,

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[4] J. Krebs-Smith, et al., "Variety in Foods," *What Is America Eating?* (New York, NY: National Academy Press, 1986).

[5] Ibid.

[6] U.S. Department of Agriculture, Economic Research Service, *U.S. Food Expenditures, 1954-78: New Measures at Point of Sale and by Type of Purchaser*, AER-431, Washington, DC. The USDA statistic is considerably higher than that reported by the U.S. Bureau of Labor Statistics. In that survey, eating away from home represented 28 percent of all personal consumption expenditures for food by 1983, an increase from 24 percent 10 years earlier. The USDA series includes expenditures for foods in places where food sales are not the main enterprise (such as hotels and motels, airlines, recreation places, military installations, and retail stores) and also includes the value of government food subsidies (such as the school lunch program). It is difficult to determine whether differences in definitions can account for the magnitude of the difference.

[7] John M. Connor, et al., *The Food Manufacturing Industries* (Lexington, MA: D.C. Heath & Co., 1985), pp. 24-25.

[8] U.S. Department of Agriculture, Economic Research Service, "Food Consumption, Prices and Expenditures 1963-83," Statistical Bulletin No. 713, Washington, DC, 1984.

[9] A. Arbel, "Higher Energy Cost and the Demand for Restaurant Services—A Time-Series Analysis," *International Journal of Hospitality Management*, vol. 2, No. 2, 1983, pp. 83-87.

[10] J. Kinsey, "Food Away From Home Expenditures by Source of Household Income," paper presented at the annual meeting of Agricultural Economics Association, Clemson, South Carolina, 1981.

[11] John M. Connor, review comment, Department of Agricultural Economics, Purdue University, 1987.

[12] U.S. Department of Commerce, Bureau of Economic Analysis, "Franchising in the Economy, 1982-1984," report, Washington, DC, 1984.

Table 3-1.—Dining Out, 1985

Restaurant type	Proportion of occasions
A. Diners' Preferences	
Quick-service (primarily fast-food)	**64.1%**
Hamburger	24.7
Pizza	10.8
Chicken	5.3
Ice cream	4.4
Sandwich	3.5
Donut	2.1
Mexican	1.9
Fish/seafood	1.4
Oriental	0.6
All other	9.4
Midscale (table service, limited alcohol)	**27.1%**
Varied menu	9.7
Family style	4.0
Cafeteria	3.1
Family steak	2.2
Oriental	0.9
Fish/seafood	0.6
Italian	0.6
Mexican	0.6
All other	5.4
Upscale (full-service)	**8.8%**
Varied menu	4.2
Hotel	1.2
Fish/seafood	0.8
Mexican	0.8
Oriental	0.7
Italian	0.4
Steak	0.4
All other	0.3

	Average number of meals per week
B. Who Dines Out	
All individuals	**3.7**
Men	4.2
Women	3.4
Household size:	
One member	4.3
Two members	3.1
Three members	3.9
Four members	4.1
Five or more members	3.7
Household income:	
Under $10,000	2.8
$10,000-14,999	3.2
$15,000-19,999	3.6
$20,000-24,999	3.7
$25,000-34,999	3.8
$35,000-49,999	4.5
$50,000 and over	4.6

C. Dining Dollars	Percent of food dollar spent away from home
1955	25.0%
1967	29.2
1972	33.6
1977	37.4
1982	38.2
1983	39.5
1985 (est.)	40.0

SOURCE: National Restaurant Association, 1985, cited in "Leisure Lifestyles," *The Wall Street Journal*, Apr. 21, 1986, p. 180.

4.9 percent Mexican food, 4.5 percent seafood, and 2.4 percent pancakes.

Nutritional Consequences

General Trends

Has all this led to a more healthy diet? The question is vexing because of uncertainties about the links between diet and health. Nutritional factors have been linked to a number of chronic diseases, such as cancer, diabetes, heart disease, and osteoporosis. Researchers are generally agreed that over-consumption of foods high in fat, salt, or cholesterol significantly increases the risk of heart disease. Some researchers have estimated that 30 to 60 percent of cancers stem from dietary factors.[13] Cancer appears to need both an agent that creates a mutation in DNA and a "promoter" agent that leads to tumor growth. Some foods may actually be "antipromoters" and inhibit tumor formation.[14] But since it is difficult to link the disease with specific diets or foods, nutritionists remain tentative in recommending preventive steps. The risk of giving misleading information must be weighed against the likelihood that the information can help improve people's health.[15]

The risks of contamination in food from pesticides and other sources remain controversial. Standards for processed and fresh foods differ greatly. Many foods have naturally occurring chemicals that are highly carcinogenic. Net risk proves difficult to establish.[16]

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[13] National Academy of Sciences, National Research Council, *Diet, Nutrition, and Cancer* (Washington, DC: National Academy Press, 1982), pp. 1-14.

[14] L.A. Cohen, op. cit., footnote 2.

[15] The National Research Council's Committee on Diet, Nutrition, and Cancer concluded in 1982 that "cancers of most major sites are influenced by dietary patterns." But the committee further concluded that "the data are not sufficient to quantify the contribution of diet to the overall cancer risk or to determine the percent reduction in risk that might be achieved by dietary modifications." See Jean-Pierre Habicht, "The Role of Nutrition Research in Policy and Program Planning," in *What Is America Eating?* op. cit., footnote 4, pp. 144-147.

Adherence to emerging dietary guidelines designed to lower the risk of specific diseases may lead to nutrient intakes below the Recommended Daily Allowances (RDAs) established by the National Research Council's Food and Nutrition Board for the nutrient needs of healthy individuals in the United States. Which guideline is then correct? One expert has observed that:

> . . . lowering of recommended total fat and salt intakes for disease prevention is almost always incompatible with American palates and pocketbooks if the diet must also fulfill all the RDAs. If one also wants to consume a diet with fewer potential carcinogens and more protective factors against cancer, attaining the RDAs is jeopardized even more.[17]

Conversely, adherence to some diets that satisfy the RDAs could increase health risks.[18]

Increasing variety of foods can also improve diet. Consumption of a greater variety of foods has been associated with a higher degree of compliance with established dietary guidelines; greater variety has been positively correlated to higher intakes of each of 11 nutrients.[19]

Americans have enjoyed a steady increase in average per capita consumption of virtually all critical minerals and nutrients. In recent years, consumption of products high in saturated fat and cholesterol has declined—animal fats by 20 percent, eggs by 19 percent, and whole milk by 58 percent. Consumption of "other milk beverages," which include lowfat and skim milk, increased a spectacular 300 percent in 20 years.[20] Consumption of cholesterol declined from a peak of 570 mg/capita in the late 1950s to 480 mg/capita in 1985 (there has been no measurable decline since 1975). The American Heart Association diet recommends 300 mg/day of cholesterol—200 mg/day for those with elevated cholesterol levels in their blood.[21] A recent study indicates that 81 percent of Americans knew about the health effects of cholesterol in 1986; the same survey found that while only 23 percent claim to have actually changed their eating habits as a result of this information, this percentage is nearly double that of 1983.[22]

High fat diets have been linked with breast cancers, and there is weaker evidence linking high fat/low fiber diets to cancers of the colon, pancreas, ovaries, and prostate. The fact that different kinds of fats and fibers appear to have different effects has greatly complicated efforts to construct links. For example, Eskimos in Greenland and people living in Greece and Spain have comparatively low levels of breast cancer even though they have high fat intake—possibly because the fat was derived from fish and olive oil.[23] While per capita consumption of animal and vegetable fats rose rapidly between 1900 and the 1960s, between 1965 and 1985 per capita consumption of animal fats declined 20 percent while consumption of vegetable fats and oils increased 60 percent.[24]

As refrigeration replaced salting, pickling, and smoking as a form of food preservation, deaths from gastric cancer fell sharply. The Japanese, who still eat a significant amount of food preserved in traditional ways, suffer far higher rates of stomach cancer.

After increasing 56 percent between 1965 and 1981, alcohol consumption per capita has since fallen steadily, declining 8.6 percent between 1981 and 1985. Beer consumption also began declining in 1981, falling to 34.5 gallons per person per year in 1985, as has consumption of distilled spirits. Wine consumption has increased steadily since 1965 (to 3.8 gallons per person per year in 1985). In 1985, more than 14 percent of the total consumption of wine was in the form of "coolers," a mixture of wine and fruit juice.[25]

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[16] During 1987, two studies conducted by the U.S. General Accounting Office found that less than 0.1 percent of imported food was checked for illegal pesticides or high levels of legal chemicals like lead. Two studies by the National Academy of Sciences criticized the U.S. Department of Agriculture's poultry inspection and techniques for determining carcinogens in tomatoes, potatoes, oranges, apples, pork, and a variety of other common products. Cited in Keith Schneider, "Congress Looks to the American Table Amid Questions on Food Safety," *The New York Times*, Jan. 22, 1987, p. A14.

[17] J.P. Habicht, op. cit., footnote 15.

[18] Johanna T. Dwyer, "Nutrition Education," *What Is America Eating?* op. cit., footnote 4; see also J.P. Habicht, op. cit., footnote 15.

[19] J. Krebs-Smith, et al., op. cit., footnote 4, pp. 126-140.

[20] K.L. Bunch, op. cit., footnote 3.

[21] D.M. Hegsted and R.J. Nicolosi, "Individual Variation in Serum Cholesterol Levels," *Proceedings of the National Academy of Sciences* , vol. 84, No. 17, Sept. 2, 1987, p. 6259; L. Roberts, "Measuring Cholesterol Is As Tricky As Lowering It," *Science*, vol. 238, No. 4826, Oct. 23, 1987, pp. 482-83.

[22] "Cholesterol Awareness Survey," The National Heart, Lung and Blood Institute of the National Institute of Health, Bethesda, MD, Dec. 4, 1986.

[23] L.A. Cohen, op. cit., footnote 2, p. 46.

[24] K.L. Bunch, op. cit., footnote 3, p. 39.

Averages, of course, can hide a number of ills. Serious defects in diets remain for special populations such as the elderly, the homeless, the poor, migrant laborers, female-headed households, pregnant women, and psychologically debilitated people.

Unfortunately, there is no reliable information on the diets and nutritional status of the population at risk.[26] There are other important gaps in our knowledge because existing surveys are not comprehensive or are out of date. By one estimate, however, there may be as many as 12 million children and 8 million adults who are chronically short of nutrients necessary for growth and good health. The National Household Food Consumption Survey of 1982 found that more than 80 percent of households where spending on food was similar to that of food stamp-recipients failed to obtain the RDAs.[27] An examination of households at risk of poor nutrition indicates that in 1977, 12 percent of Americans were not getting enough food energy and nearly one-quarter failed to get enough vitamin B-6 (see table 3-2). Given a continuation of present trends, the analysis suggests that the dietary status of the population will actually worsen in terms of five out of six components examined. About one-quarter of U.S. households would continue to have availability levels of calcium and vitamin B-6 below 75 percent of the RDA in 1995. The GNP would have to increase much faster than 3 percent annually to make a marked improvement on the dietary availability of some nutrients for the groups receiving inadequate nutrition.

Table 3-2.—Percentage of Households With Selected Dietary Availability Levels Below 75 Percent of the Recommended Daily Allowance (1977/78 and 1995, assuming 3 percent annual growth in GNP)

Year	Food energy	Calcium	Iron	Magnesium	Vitamin A	Vitamin B-6
1977 . .	11.9	24.4	8.0	13.6	16.7	23.4
1995 . .	12.6	25.2	8.4	14.0	15.8	24.0

SOURCE: "Future Food Patterns of the U.S. Population," cooperative agreement between the University of Missouri at Columbia and the Office of Technology Assessment, No. 433-7130.0, October 1985.

Claims that Americans are going hungry have been disputed using statistics showing no increase in childhood anemia. Given the poverty of data it is difficult to resolve the issue with precision. For example, not much is known about the relationship between the supply of food and its utilization by specific individuals and various types of households. The per capita food consumption series maintained by USDA provides only crude consumption estimates for the "average" American. Only one national survey, the 1977 to 1978 National Food Consumption Survey (NFCS), is currently available for assessing major variations in food consumption among individuals and households within the U.S. population. Limited annual surveys initiated by USDA in 1985 (Continuing Survey of Food Intakes by Individuals) will improve this database.

Even assuming that data on nutritional status were much improved, scientific understanding of the health consequences of diet remains tentative in many respects. Probably the most salient example concerns the RDAs. Simply put, the specific health risks associated with nutrient intakes below the RDAs remain largely unknown.[28]

Eating Away From Home

The increase in eating out is complicating dietary assessments. According to one estimate, the 16 percent of all eating and drinking occasions that occur away from home supply 18 percent of total food energy and about 16 percent of most vitamins and minerals. Men and children consume more of their food away from home than do women, and so obtain more of their food energy and nutrients from those occasions.[29]

One recent study of snacking and away-from-home eating indicated that "where and when foods were consumed had very limited impact on their nutritional status."[30] The researchers noted, however, that future investigations might profitably focus on those who are nutritionally at risk. Furthermore, the away from home share of food expenditures has increased since 1977 and will probably continue to do so over the next decade. The nutritional consequences of this important trend warrant more attention.

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[25] Ibid., p. 5.

[26] J.P. Habicht, op. cit., footnote 15.

[27] J.L. Brown, "Hunger in the U.S.," *Scientific American*, vol. 256, No. 2, February 1987, pp. 37-41.

[28] Betty B. Peterkin, "Assessment of Diet Quality and the U.S. Department of Agriculture's Nutrition Policy and Research," *What Is America Eating?* op. cit., footnote 4.

[29] Robert B. Reese and Sharon J. Mickle, "Where to Eat—At Home or Away?" *1982 Yearbook of Agriculture* (Washington DC: U.S. Government Printing Office, 1983).

[30] Karen J. Morgan and Basile Goungetas, "Snacking and Eating Away from Home," *What Is America Eating?* op. cit., footnote 4, p. 123.

Choices and Consequences

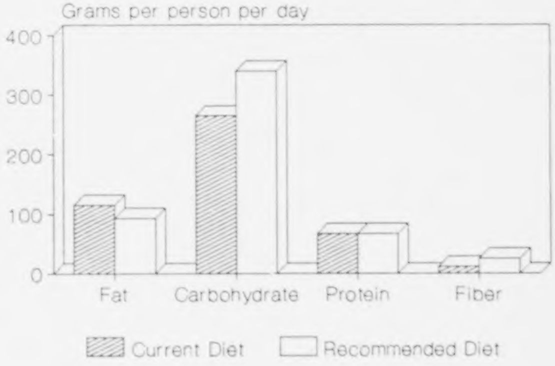
The Trend scenarios for expenditure on the Food amenity (as defined in ch. 2) are based on present patterns of household expenditure, and no significant changes in regulatory programs affecting food prices. The Alternative scenarios differ in that they assume that all Americans have access to a healthy diet and that all income groups pay more attention to the health consequences of their diet. Figure 3-1 indicates the changes that would occur in American eating habits if the recommendations of the National Research Council and other recent studies of diet and health were followed.

While they do not correspond precisely to the recommendations shown in figure 3-1, USDA has developed estimates of "nutritious" diets that could be purchased by households with different incomes. These diets contain recommended intake of calories and nutrients and would reduce fat, cholesterol, sweeteners, and sodium below current levels. They contain more grain products, vegetables, and fruits, and less cheese, eggs, fats, oils, sugar, and soft drinks, than are now eaten in most U.S. households. These diets were used to explore the implications of a shift to a different pattern of food consumption in America. The "liberal" USDA diet was used as an estimate of the way Americans might eat if the U.S. gross national product (GNP) grew 3 percent per year and the "moderate cost" diet was used for the 1.5 percent case. These plans are based on the eating habits of the upper half of all households ranked by expenditure on food.

Food expenditures at home and away from home for the different scenarios are given in table 3-3. The total value of purchases of the Food amenity (including alcohol) is actually lower in the Alternatives than in the Trend cases, even though they explicitly provide healthy, balanced diets for all Americans and assume a continued increase in purchases of food away from home.

The Alternative cases assume that expenditures on cigarettes and alcohol fall below the Trend cases. These estimates are based on a continuation of past trends in per capita consumption expenditures—roughly, a 1.6 percent annual increase in alcohol consumption between 1960 and 1983, and a −0.9 percent decrease in tobacco between 1973 and 1983.

Figure 3-1.-Current and Recommended Diet



SOURCE: L.A. Cohen, "Diet and Cancer," *Scientific American*, November 1987, p. 48; and National Cancer Institute, Division of Cancer Prevention and Control, "Annual Cancer Statistics Review," January 1988.

HEALTH

Society's Recipe for Health

The debate over the proper recipe for good health must be one of mankind's oldest. Although health and life expectancy depend partially on hereditary factors, many aspects of health can be influenced or controlled by individual or social actions. These include the following:

- Time and energy spent in promoting one's own health or avoiding illness, including the time needed to remain informed about appropriate health strategies and any loss of amenity associated with changes in lifestyle required to promote good health (e.g., avoiding fast driving, smoking, drinking, and inappropriate diets).
- Disease prevention through vaccination and

Table 3-3.—Consumption Scenarios for Food (billions of 1983 dollars)

		2005			
	1983	Trend 3%[a]	Trend 1.5%[a]	ALT 3%[b c]	ALT 1.5%[c]
Food and alcohol					
At home	298.4	433.0	402.0	387.0	321.0
Away from home	123.6	235.0	146.8	259.0	164.0
Tobacco	28.0	31.2	35.5	22.0	25.0
Total Food in personal consumption expenditures	450.0	699.2	584.3	668.0	510.0
Government purchases of food	1.7	3.3	2.4	3.3	2.4
Total	451.7	702.5	586.7	671.3	512.4
Percent share of gross national product	13.2	10.7	12.4	10.3	10.9

[a] Computed from extrapolative analysis discussed in ch. 2; Trend = Trend Scenario.

[b] Expenditure in ALT 3% food at home (excluding tobacco) in the ALT case is similar to estimates made by J. Blaylock and D. Smallwood ("Projected Growth in American Food Spending," National Food Review #32, U.S. Dept. of Agriculture (USDA)); ALT = Alternative Scenario.

[c] The 118.6 million households in 2005 are divided into 3 categories, single households (28.2 million), family of 2 (33.8 million), and the rest, assumed family of 4 (56.7 million). The number of households in each group is multiplied by the U.S. Department of Agriculture estimate of the weekly cost of a nutritious food plan, using the moderate cost plan for the 1.5% scenario and the liberal plan for the 3% scenario. (See U.S. Department of Agriculture, Consumer Nutrition Division, *Family Food Plans 1983*, March 1983.) The costs are as given below:

	Dollars per week	
	Liberal	Moderate
Single member family	34.6	28.1
2 member family	60.8	50.3
4 member family	90.7	80.3

The resulting totals are then calculated on an annual basis. The annual totals, which are based on the assumption that all meals are taken at home, are then adjusted to take into account meals outside the home.

It is assumed that in the moderate cost plan, one meal in five is taken out of the home. One-fifth of the estimated Food expenditure is therefore deducted from the total and doubled in value (approximately 20% of all Food and 40% of all spending for food was away from home in 1983—see text). In the liberal food plan it is assumed that one meal in four is taken away from home.

Alcohol is estimated independently, and then divided between food at home and food away from home categories at the 1983 levels (60 and 40% respectively). For 3% case, (real) per capita expenditure on alcohol is increased by annual average of 1.6% (as during 1960-83 period, multiplied by 2005 population). For 1.5% case, consumption is assumed to be one-half of 3% ALT.

Per capita tobacco consumption in the 3% growth case is assumed to decline 22%, roughly following 1973-83 trends projected to 2005. Consumption in the ALT 1.5% case is reduced by the ratio between low growth and high growth tobacco consumption computed for the trend cases.

SOURCE: Office of Technology Assessment, 1988.

early detection of disease, by routine testing for such things as high blood pressure and cancer.

- Public investments in such things as air and water pollution abatement (public spending for pollution control and other health and safety objectives increased from approximately $7 billion in 1972 to a peak of $9.7 billion in 1978, then fell to $8 billion in 1983).[31]
- Investments in occupational health and safety.
- Aspects of home- or work-life that contribute to stress.
- Purchases of treatment to remedy problems once they have occurred.

In principle, it should be possible to compare the relative benefits of investments in each of these categories.[32] Given current state of knowledge about the determinants of health, this proves impossible in practice. The situation is made all the more confusing by the rules governing health spending. Only the patient has a clear incentive to optimize spending to maximize real health, yet the patient may not be well informed of alternatives, and may not be in control of the choices made in her name.

The economics of health involve a complex combination of public funding, public regulation, and private decisionmaking. Health markets differ from ordinary markets in several important ways:

1. The flow of information between provider and client in the market for health services is unlike that in other markets, depending more heavily on trust among the clients and professional integrity among the providers. Furthermore, the parties are frequently on an unequal footing.[33] There are even cases where it may

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[31] Andrew Martin, "Public Health and Safety," contract report prepared for the Office of Technology Assessment, 1985.

[32] A formal theory of the "production function" of health is suggested in several sources. See, for example, Michael Grossman, *The Demand for Health* (New York, NY: National Bureau of Economic Research, 1972); H.L. Blum, *Planning for Health* (New York, NY: Human Sciences Press, 1974); and Jack Hadley, *More Medical Care, Better Health?* (Washington, DC: Urban Institute Press, 1982).

[33] Frances H. Miller, "Secondary Income From Recommended Treatment: Should Fiduciary Principles Constrain Physician Behavior," in Bradford H. Gray (ed.), *The New Health Care for Profit* (Washington, DC: National Academy Press, 1983).

be ethically (and legally) possible to withhold information from the individual being treated.

2. Many kinds of competitive behavior that would be celebrated in ordinary commercial competition cannot be permitted in the practice of medicine. While it is difficult to raise complaints about an enterprise that manages to sell individuals more shoes than they need (indeed, much of the U.S. economy depends on consumption that goes beyond need), there is general consensus that it is unethical to encourage a patient to purchase more medical treatment than is needed. The medical community now accepts the patenting of drugs, devices, and techniques,[34] but controversy continues over whether it is appropriate for physicians to sell drugs and other products directly to patients.
3. Perhaps most importantly, health care involves a complex mixture of personal, corporate, and government decisions. In 1950, two-thirds of medical spending came directly from patients. By 1983, 73 percent of all medical spending came from insurance companies or government programs such as Medicare and Medicaid.[35]

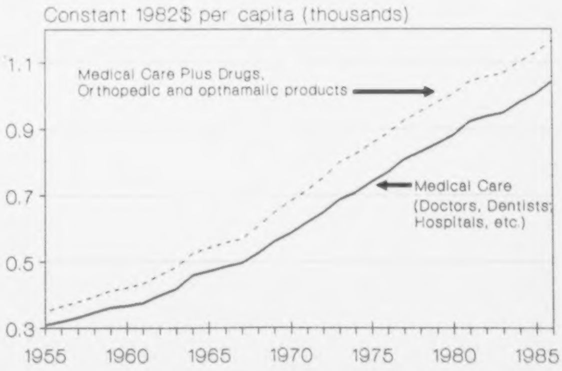
The Record

American spending on health has grown rapidly since the 1970s, because of the availability of new and increasingly expensive technology, public programs providing the elderly and the poor with greater access to health care, the difficulty of increasing productivity in a business dominated by personnel costs, and a variety of other factors. Health care costs have risen at an average rate of 1.75 percent faster than all personal expenditure costs since the 1950s, and in spite of efforts to contain costs, health care costs increased more than 2.5 percent a year between 1980 and 1986.[36] These statistics must be treated with considerable caution since our ability to measure inflation in health care in a period of rapid change is plainly limited. For example, an appendectomy conducted in 1986 may appear identical to one performed in 1972, but advances in medical practice are likely to make the 1986 procedure safer.

While the relative role of the different factors contributing to health costs proves difficult to disentangle (a modest effort is made in ch. 6), the result has been a spectacular growth in per capita health care spending. Figure 3-2 shows changes in per capita spending for health care. Real per capita spending (that is spending adjusted for inflation) increased an average of 5 percent per year between 1972 and 1986. The growth in spending is much higher than would be expected by the aging of the U.S. population.

Explaining the links between spending and expected outcomes in U.S. health care is a treacherous undertaking. It proves virtually impossible to use available statistics to disentangle decisions made in response to competent medical advice (e.g., decisions to smoke, drive without seat belts, and engage in lifestyles likely to decrease health status), decisions made in ignorance of the proper way to use the medical enterprise, and decisions made in ignorance about the health implications of behavior. The problem is made all the more difficult by the extent to which a unique set of regulations strongly affects the way consumer desires for good health translate into market incentives in the business community. Cir-

Figure 3-2.-Per Capita Spending for Medical Care



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 2.5.

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[34] Robert M. Veatch, "Ethical Dilemma of For-Profit Enterprise in Health Care," B.H. Gray, op. cit., footnote 33.

[35] U.S. Department of Health and Human Services, *Health, United States: 1985* (Washington, DC: U.S. Government Printing Office, December 1985).

[36] More precisely, the ratio of the deflator for "medical care" to the deflator for all "personal consumption expenditures" increased by 1.75 percent per year from 1955 to 1986, based on a regression of data provided in U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, *Survey of Current Business*, table 7.10.

cumstantial evidence suggests, however, that the performance of the U.S. health care system could be dramatically improved without any changes in medical technology.

Recent Trends

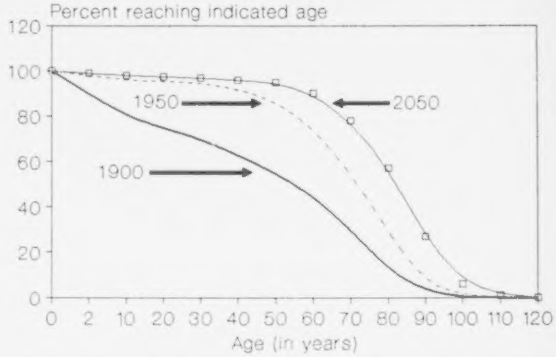
While it is difficult to determine which factor deserves credit, the health status of the average American has clearly improved during the past few decades. An individual born in the United States in 1984 could expect to live 74.7 years—6.5 years longer than an individual born in 1950. Someone aged 65 in 1950 could expect to live an additional 13.9 years, while a person reaching 65 in 1984 could expect to live an additional 16.8 years.[37] Infant mortality rates fell from 29.2 per thousand in 1950[38] to 11.2 per thousand in 1983 (rates of improvement have fallen somewhat since 1981).

Average improvements in life expectancy have not eliminated the striking difference between life expectancies of different American social groups. Age adjusted death rates for black males, for example, were nearly 50 percent higher than those of white males in 1983.[39]

As figure 3-3 indicates, improved rates of infant mortality may be the most important factor behind increases in average life expectancies; the figure suggests that a decline in deaths at an early age has played a comparatively larger role in lengthening average U.S. life spans than has the fact that older people are living longer.

The factors leading to the improvements in health status are extremely difficult to disentangle. It does appear that as a result both of improved clinical techniques and increased funding of health care for the poor, death from diseases where medical treatment can save lives declined sharply between 1968 and 1980. Deaths from childbirth declined 72 percent, from influenza and pneumonia 53 percent, from tuberculosis 52 percent, and from diabetes 31 percent.[40] Death rates from heart disease and stroke have been declining since 1940. Between 1970 and 1983, age-adjusted death rates from heart disease fell 26% while death rates from stroke were cut in half. There is some evidence that this fall is associated with a decline in cigarette smoking, high serum cholesterol, elevated blood pressure, and lack of exercise. Improvements in medical care have also played an important role.[41] It proves to be nearly impossible, however, to allocate credit for reduced heart disease directly.[42]

Figure 3-3.-Changes in Patterns of Mortality



How to Read This Figure: Given the mortality rates of 1900, 54% of all people would reach age 60. Using mortality rates of 1950, 75% of all people reach age 60.

SOURCE: U.S. Department of Health and Human Services, Social Security Administration, "Life Tables for the United States, 1900-2050," Actuarial Study No. 89, Baltimore, MD, December 1983.

In contrast, death rates from the other major killer, cancer, have risen slightly, growing from 157 deaths per 100,000 in 1950 to 171 per 100,000 in 1985. This is largely because of increasing incidence of lung cancer resulting from smoking. Death rates from stomach, uterine, and some other cancers have declined slightly during the past 20 years. Deaths from all cancers *except* lung cancer fell from 144 per 100,000 in 1950 to 125 per 100,000 in 1985.[43]

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[37] U.S. Department of Health and Human Services, *Health, United States, 1984* (Washington, DC: U.S. Government Printing Office, December 1984).

[38] U.S Department of Health, Education, and Welfare, Public Health Service, *Health Status of Minorities and Low-Income Groups* (Washington, DC: U.S. Government Printing Office, 1979).

[39] U.S. Center for Health Statistics, *Vital Statistics of the United States*, cited in U.S. Bureau of the Census, *Statistical Abstract of the United States: 1987* (107th ed.), Washington, DC, 1986.

[40] U.S. Center for Health Statistics, unpublished data for 1982, cited in D.E. Rogers, R.J. Blendon, and T.W. Moloney, "Who Needs Medicaid?" *New England Journal of Medicine*, vol. 307, No. 1, July 1, 1982, pp. 13-18.

[41] U.S. Department of Health, Education, and Welfare, Public Health Service, "Healthy People: The Surgeon General's Report on Health Promotion and Disease Prevention," DHEW (PHS) Publication No. 79-55071, 1979; U.S. Department of Health, Education, and Welfare, Public Health Service, Proceedings of the Conference on the Decline in Coronary Heart Disease Mortality, National Heart, Lung, and Blood Institute, National Institutes of Health, NIH Publication No. 79-1610, 1979.

[42] S. Pell and W.E. Fayerweather, "Trends in the Incidence of Myocardial Infarction and in Associated Mortality and Morbidity in a Large Employed Population, 1957-1983," *New England Journal of Medicine*, vol. 312, No. 16, Apr. 18, 1985, pp. 1005-1011.

Risk factors in the development of other cancers include: alcohol, smoking, certain viral infections, and exposure to cancer-causing substances in the workplace, in the general environment, or in food and drugs. Research is underway to determine whether high fat/low fiber diets also contribute. Heredity may also play a role. While remarkable advances in treatment for certain types of cancer have occurred, it is not clear that the increase in survival for the more common cancers is due to improved medical care.[44]

As life expectancy rates increase, other health indicators appear to be changing as well. Since 1973, the percentage of the population reporting some limitation of activity has remained essentially the same, while the average number of restricted-activity days per person per year increased from 14.6 days in 1970 to a peak of 19.1 in 1980 and 1981 and fell to 14.5 days in 1983. Blacks have more restricted-activity than whites (16.6 v. 14.3 in 1983). Bed-disability days remained roughly constant for people under 65 (5.3 days/year in 1970 v. 5.4 days/year in 1983) but rose steadily for those over 65 (13.8 days/year v. 16.7 days/year in 1983).[45]

The changes (particularly the reversal of reported disability since 1981) are difficult to interpret. The number of days each American is likely to spend in poor health is in part symptomatic of improved medical technology, such as the development of diagnostic techniques resulting in earlier awareness of disease. Changing public attitudes toward disability, improved social supports for the disabled, and changes in employer-granted sick leave may also increase the reporting of disability. The changing figures may also be a result of medical progress, which is able to save lives but not necessarily prevent lengthy periods of illness.[46]

Factors Influencing American Health

The United States spends as much or more for health care per person than any nation in the world, yet U.S. life expectancy rates are lower and infant mortality rates higher than they are in many other advanced economies. Moreover, different States within the United States exhibit a range of life expectancies that have little obvious relation to spending on health care. Average male life expectancy in Hawaii, for example, was higher than that recorded by any nation in the world in 1981, while life expectancy in Louisiana was lower than that in Cuba, Singapore, and Bulgaria.[47]

The life expectancy of Seventh Day Adventists living in California is more than 11 years longer than the U.S. average. U.S. life expectancy could increase by 0.7 years if rates of mortality in 1984 were equal to that of the white population in the United States, and 5.1 years longer if average U.S. mortality rates were raised to that of the healthiest geographic regions in the United States. This exceeds the 4.4 year gain in life expectancy achievable by eliminating cancer.[48] Achieving these gains would require *both* changes in access to high quality medical care and changes in the social conditions and lifestyles that may create higher incidence of disease in the least healthy population groups.

While there are many unanswered questions, differences in health status are obviously linked to the following factors:

- hereditary factors;
- diet, driving habits, stress, and other aspects of lifestyle;
- preventive medicine;
- access to health care for treatment of illness and appropriate use of health care; and
- the quality of the care delivered, including technical advances.

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[43] U.S. Department of Health and Human Services, National Cancer Institute, "Annual Cancer Statistics Review," summary, Washington, DC, January 1988.

[44] P.M. Boffey, "Cancer Progress: Are the Statistics Telling the Truth?" *The New York Times*, Sept. 18, 1984; A.R. Feinstein, D.M. Sosin, and C.K. Wells, "The Will Rogers Phenomenon: Stage Migration and New Diagnostic Techniques as a Source of Misleading Statistics for Survival in Cancer," *New England Journal of Medicine*, vol. 312, No. 25, June 20, 1985, pp. 1604-1608.

[45] U.S. Center for Health Statistics, *Vital and Health Statistics*, Series 10, cited in *Statistical Abstract of the United States: 1987*, op. cit., footnote 39, Table 160.

[46] L.M. Verbrugge, "Longer Life but Worsening Health?: Trends in Health and Mortality of Middle-aged and Older Persons," Milbank Memorial Fund Quarterly, *Health and Society*, vol. 62, 1984, pp. 475-519.

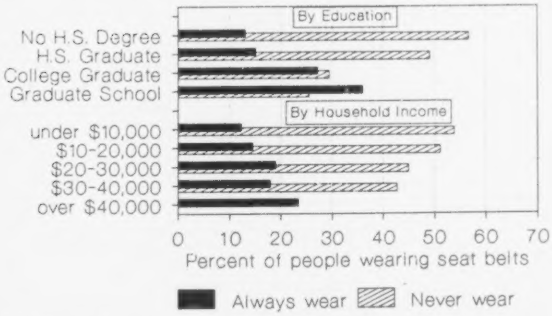
[47] The Japanese, one of the world's longest-lived peoples, take far less interest in smoking cessation than does the United States.

[48] See U.S. Congress, Office of Technology Assessment, "Health," sector study, Washington, DC, 1987.

Social class, measured by levels of education, income, or occupation, affect many of these variables and correlate strongly with mortality and morbidity rates.[49] Even psychological illnesses, like depression and schizophrenia, are strongly linked to social class.[50] It is, of course, often difficult to distinguish cause from effect when examining correlations, since poor health is often a direct cause of low income.

Education seems to be strongly correlated with good health if only because education is correlated with income.[51] Education appears to be connected with knowledge about health effects of lifestyles and the way health care facilities can be used. Figure 3-4, for example, shows the strong connections between use of seat belts and education. Similarly, the mortality rates of well educated white males aged 25-63 are significantly lower than those in the same group with comparatively poor educations.[52] Women with low levels of education have a much higher number of babies with low birthweights.[53]

Figure 3-4.-Seat Belt Use in 1983



SOURCE: U.S. Department of Transportation, Federal Highway Administration, "Personal Travel in the U.S.—A Report on the Findings From the 1983-1984 Nationwide Personal Transportation Study," Volume I, Washington, DC, August 1986, tables 10-2 and 10-3.

Strong social ties, measured by numbers of social contacts, church membership, and membership in social organizations, appear to be correlated with low mortality rates.[54] Evidence of the strong correlations between behavior and health is also evidenced by the fact that marriage is strongly correlated with longer life expectancy. Men appear to benefit more from marriage than women.[55]

Hereditary Factors.—Hereditary factors may explain some of the differences in health status of nations and States that appear to have access to identical medical technology. Japanese living in America assume most American patterns of disease, and black Americans have patterns of disease that more closely resemble those of Caucasians than those of West Africa.[56] In fact, Japanese living in California considered "acculturated" to American lifestyles had coronary heart diseased 2.5 to 5 times higher than a group that lived in California but had not adopted Western lifestyles.[57]

Environmental and Lifestyle Factors.—The potential benefits of some measures to prevent disease and promote good health are well established. Smoking, failure to wear seat belts, alcohol abuse, improper diet, dangerous working conditions, stress resulting from unemployment or other causes, exposure to air or water pollution, and a variety of other factors contribute to poor health status. There is reason to believe that most of the improvements in life expectancy achieved between 1900 and 1970 resulted from improved income and living conditions rather than improvements in clinical medicine.[58]

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[49] E.M. Kitegawa and P.M. Hauser, *Differential Mortality in the United States* (Cambridge, MA: Harvard University Press, 1973).

[50] S.L. Syme and L.F. Berkman, "Social Class, Susceptibility and Sickness" *American Journal of Epidemiology*, vol. 104, No. 1, July 1976, pp. 1-8.

[51] Based on data by region in the 1970 U.S. Census, cited in J. Hadley, op. cit., footnote 32, pp. 59-61.

[52] E.M. Kitegawa and P.M. Hauser, op. cit., footnote 49.

[53] Institute of Medicine, *Preventing Low Birthweight* (Washington DC: National Academy Press, 1985). See also U.S. Congress, Office of Technology Assessment, *Neonatal Intensive Care for Low Birthweight Infants: Costs and Effectiveness*, Health Technology Case Study 38 (Washington, DC: Government Printing Office, December 1987).

[54] The correlation appears even when corrections are made for factors like smoking, obesity, health practices, and health status. A study of Alameda County, California showed strong correlations between social networks and health outcomes. See S.L. Syme and L.F. Berkman, "Social Networks, Host Resistance, and Mortality: A Nine-year Follow-up Study of Alameda County Residents," *American Journal of Epidemiology*, vol. 109, No. 2, February 1979, pp. 186-204. Other studies have found similar, but much weaker correlations; see Syme and Berkman, 1976, op. cit., footnote 50, for a review.

[55] Widowed and divorced individuals have a higher mortality rate than single (never married) or married individuals. See V. R. Fuchs, *Who Shall Live* (New York, NY: Basic Books, 1974), pp. 50-51; G.H. Orcutt et al., "Does Your Probability of Death Depend on Your Environment?" *American Economic Review*, vol. 67, No. 1, February 1977, p. 264; M.C. Sheps, "Marriage and Mortality," *American Journal of Public Health*, vol. 51, No. 4, April 1961, p. 547.

[56] Black Americans have cancer rates more similar to those of white Americans than those of the West African populations from which they originated. Japanese living in Hawaii have cancer rates with patterns more closely resembling those of Caucasians in Hawaii than Japanese in their homeland. In 1970-71, for example, breast cancer occurred at a rate of 300/million people in Japan, about 1,200/million for Japanese in Hawaii, and 1,800/million for Caucasians in Hawaii. On the other hand, stomach cancer incidence was 1,300/million in Japan, 400/million for Japanese in Hawaii, and 200/million for Caucasians in Hawaii. See R. Doll and R. Peto, *The Causes of Cancer* (New York, NY: Oxford University Press, 1981), p. 1201.

[57] M.G. Marmot and S.L. Syme, "Acculturation and Coronary Heart Disease in Japanese-Americans," *American Journal of Epidemiology*, vol. 104, No. 3, September 1976, pp. 225-247.

It is estimated, for example, that 25 to 40 percent of cancer deaths result from smoking and 10 to 70 percent from diet.[59] A significant part of the credit for the reduction in mortality due to cardiovascular disease during the 1970s resulted from changes in diet, exercise habits, and other factors independent of clinical medicine. Control of hypertension through therapeutic pharmaceuticals obviously played a major role in addition to advances in heart surgery and other spectacular therapeutic improvements that occurred during the same period.[60]

Infant mortality and birth defects are strongly linked to prenatal care for the mothers. Two-thirds of all infant deaths occur when the baby is born weighing less than 5.5 pounds.[61] Poor nutrition, smoking, exposure to toxic substances, alcoholism, and a variety of other conditions contribute to low birthweights and a variety of medical conditions before and after birth.[62]

Accidents, which account for 6.5 percent of all deaths and are the leading cause of death for those below the age of 44, provide a further illustration of lifestyle effects. Over half of all accidental deaths are due to motor vehicle accidents, and alcohol abuse is the predominant risk factor in these accidents.[63] Other factors influencing the accidental death rate include road conditions, vehicle safety design, and the use of safety devices such as seat belts, air bags, and child safety seats.[64]

Improvements in the speed with which casualties can be treated, the emergence of hospital-based casualty centers, and better rehabilitation programs are also important in reducing mortality and injury rates resulting from accidents.[65] Nearly 60 percent of accidental deaths can be prevented by adequate and timely medical care. The remaining 40 percent, however, occur immediately after the accident. The only way to reduce the mortality rate in these situations is by preventing the accident.[66]

U.S. medicine tends to leave the often complex problem of prevention in the hands of individuals, providing only the techniques for fixing problems once they occur. Hurried physicians, for example, may be more likely to prescribe drugs to control high levels of blood cholesterol than to undertake the time-consuming and difficult task of counseling changes in a patient's diet.[67]

In principle, some of the new mechanisms for financing clinical medicine, such as the self-insuring health maintenance organizations (HMOs), can go part of the way toward reconciling the two kinds of health investment. To date, however, the HMOs do not appear to have taken steps to encourage prevention that are consistently different from those taken by other medical practices.

The United States has made enormous investments to improve or at least slow the deterioration of air and water quality. Unfortunately, little is known about total exposure to potentially hazardous substances or substances that may have beneficial effects. It proves extremely difficult to link environmental hazard to specific health effects even when good data are available, because so many variables are involved. Numerous investigations have resulted in few clear correlations between typical exposure to pollutants and health effects.[68] Some studies suggest that a 1 percent reduction in pollution from "stationary source air pollution" (pollution from sources other than cars and trucks) results in a 0.1 percent reduction in mortality rates and 0.1 to 0.4 percent reduction in illness. While 1 to 3 percent of the Nation's groundwater may be polluted by hazardous waste dumps, pesticide and fertilizer runoff, and other materials,[69] little is known about long-term health effects. Improvements in drinking water at the turn of the century played a decisive role in improving health, and outbreaks of disease are only occasionally traced to poor water supplies today. It is possible, however, that low-level exposure to heavy metals and other contaminants in water has long-term health effects not easily measured.[70]

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[58] J.B. McKeowin and S.M. McKinlay, "The Questionable Contribution of Medical Measure to the Decline of Mortality in the United States in the Twentieth Century," *Health and Society*, summer 1977, pp. 405-428; T. McKeown, *The Role of Medicine: Dream, Mirage or Nemesis* (London: Nuffield Provincial Hospital Trust, 1976)

[59] Doll and Peto, op. cit., footnote 56, p. 1256.

[60] R.F Gillum, et al., "Sudden Death and Acute Myocardial Infraction in a Metropolitan Area, 1970-1980," *New England Journal of Medicine*, vol. 309, No. 22, Dec. 1, 1983, pp. 1353-1358; U.S. Department of Health and Human Services, Public Health Service, "Smoking and Cardiovascular Disease," *Morbidity and Mortality Weekly Report*, No. 32, 1984, pp. 677-679; S. Pell and W.E. Fayerweather, op. cit., footnote 42.

[61] S. Shapiro, M.C. McCormick, M.C. Starfield, et al., "Relevance of Correlates of Infant Deaths for Significant Morbidity at 1 Year of Age," *American Journal of Obstetrics and Gynecology*, vol. 136, No. 3, Feb. 1, 1980, pp. 363-373.

[62] Institute of Medicine, op. cit., footnote 53.

[63] H.J. Malin, et al., "Alcohol-Related Highway Fatalities Among Young Drivers—United States," *Morbidity and Mortality Weekly Report*, No. 31, 1982, pp. 641-644.

[64] S.P. Baker, B. O'Neil, and R.S. Karpf, *The Injury Fact Book* (Lexington, MA: Lexington Books, 1984).

[65] National Research Council and the Institute of Medicine, *Injury in America* (Washington, DC: National Academy Press, 1985).

[66] D.D. Trunkey, "Trauma," *Scientific American*, vol. 249, No. 2, August 1983, pp. 28-35.

[67] L.A. Cohen, op. cit., footnote 2.

[68] For a review of these studies, see A.M. Freeman III, *Air and Water Pollution Control* (New York, NY: J. Wiley & Sons, 1982).

While data on outdoor pollution are reasonably complete, data are extremely poor on exposures received indoors where people spend 90 percent of their time. Indoor concentrations of radon, formaldehyde, tobacco smoke, asbestos, carbon monoxide, and nitrogen dioxide are almost always greater than outdoor concentrations.[71] Pollution from office machines, household chemicals, and a host of other sources usually makes interior air much less safe than external air.

Preventive Medicine.—A variety of medical technologies have the potential to reduce mortality and sickness by early detection of disease, or by treating conditions like high blood pressure that are linked with disease. These measures, however, can be costly. There is considerable disagreement about how best to compare the costs and benefits of prevention and cure.[72] The fundamental dilemma is determining how much it is worth to prolong life, and whether different values should be attached to the quality of the life preserved. One method for resolving this issue involves the use of "discounted years of healthy life."[73] In this approach, costs include the costs of all preventive measures and any side effects less the savings from treatment costs avoided. The costs of medical care used in survivors' longer expected life have sometimes been included but are more controversial. Benefits include discounted years of added life adjusted to reflect the quality of the added years of life. (e.g., Are the years spent in pain or activity severely limited by the methods used to prolong life?)[74]

Using such measures, it has been shown that the cost of a "discounted year of healthy life saved" due to hypertension screening ranges from $3,300 (1975 dollars) for 20-year-old men to $16,300 for 60-year-old men. Costs would average $7,000 per year of life saved if the costs of a national screening program to detect hypertensives were included.[75] A study conducted on the effectiveness of Pap tests recommended one test every 3 years instead of one test every year.[76]

Clinical Treatment.—A spectacular variety of new and often expensive technologies have reduced suffering and prolonged life in the past few decades. The impact of these technologies, and the way they have reshaped the structure of the Nation's health delivery system, are discussed in chapter 6. Technical progress has been so dramatic and changes in management and regulations so rapid that it is difficult—often impossible—even for experts to provide statistically sound analyses of costs and outcomes.

The obvious links between access to care and good health are clouded not only by the difficulty of separating environmental and behavioral factors from the income available for clinical medicine, but also by the facility by which available resources are allocated and the way they are allocated. An attempt to disentangle data from the 1970 census showed a strong positive return to investments in clinical medicine. A 10-percent increase in medicaid spending per enrollee, for example, was found to decrease mortality by 1.6 percent.[77]

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[69] U.S. Congress, Office of Technology Assessment, *Protecting the Nation's Groundwater from Contamination* (Washington, DC: U.S. Government Printing Office, 1984).

[70] American Medical Association, "Drinking Water and Human Health," Chicago, IL, 1984.

[71] National Academy of Sciences, *Indoor Pollutants* (Washington, DC: National Academy Press, 1981); H. Levin, "Indoor Air Pollution Research and Its Applications in Office Building Development and Operation," *The Changing Office Workplace*, J. T. Black, et al. (eds.) (Washington, DC: The Urban Land Institute, 1986).

[72] L.B. Russel, *Is Prevention Better Than Cure?* (Washington, DC: The Brookings Institution, 1986).

[73] M.C. Weinstein and W.B. Stason, "Foundations of Cost Effectiveness Analysis for Health and Medical Practices," *New England Journal of Medicine*, vol. 296, No. 13, Mar. 31, 1977, pp. 716-721.

[74] L.B. Russel, op. cit., footnote 72, pp. 71-72.

[75] See M.C. Weinstein and W.B. Stason, *Hypertension: A Policy Perspective* (Cambridge, MA: Harvard University Press, 1976). The hypertension study reveals some of the painful choices that must be made. The discounting technique estimated that a 50-year-old man would be paying $6,900 for each discounted year of life saved ($2,300 if he is lucky enough to have complete success with the treatment). Is this too much for society to spend extending the man's life by about four years when these additional years will occur when the individual is no longer in the work force?

[76] D.M. Eddy, "The Economics of Cancer Prevention and Detection: Getting More for Less," *Cancer*, Mar. 1, 1981, p. 1200.

Adequate use of the health care system is, of course, not simply a matter of providing adequate funding. There remains the question of how patients choose to use the care. It appears, for example, that 50 percent of patients in the United States do not take prescribed medications in accordance with instructions, and some 20 to 40 percent of recommended immunizations are not obtained.[78] Scheduled appointments for treatments are missed 20 to 50 percent of the time.[79] Again, it is not obvious whether these responses reflect informed market choices or other factors. Explanations include ignorance, fear, distraction, and many others factors, in addition to an inability to afford the treatment.

Many nations with comparatively advanced economies (Sweden, the United Kingdom, Japan, Canada, and West Germany) have achieved comparable or even better national health status than the United States while devoting a smaller percentage of their GNP to health (see table 3-4). These nations all have more ambitious programs for providing universal health care coverage than the United States. Sweden and Japan, the two countries with the best health records, provide both universal health

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[77] J. Hadley, op. cit., footnote 32, pp. 59-61.

[78] D.L. Sackett, "The Magnitude of Compliance and Noncompliance," D.L. Sackett and B.B. Haynes, eds., *Compliance with Therapeutic Regimens* (Baltimore, MD: Johns Hopkins University, 1976), p. 16.

[79] J.P. Kirscht and I.M. Rosenstock, "Patient's Problems in Following Recommendations of Health Experts," G.C. Stone, et al. (eds.), *Health Psychology: A Handbook* (San Francisco, CA: Jossey-Bass, 1979), pp. 189-215, cited op. cit., footnote 50.

Table 3-4.—International Comparisons

	U.S.	Canada	U.K.	Sweden	Japan
1) Life expectancy at birth (1981):					
Male	70.4	70.8[a]	71.2	73.1	73.8
Female	77.8	78.3[a]	77.2	79.1	79.1
2) Life expectancy at age 65 (1980):					
Male	14.1	14.4[a]	13.1	14.4	14.6[b]
Female	18.3	18.7[a]	17.2	18.2	17.7[b]
3) Infant mortality rate (1981) deaths per 1,000 live births	11.9	9.6	11.1	6.8[c]	7.1
4) Health care spending as percent of gross national product	10.7	8.4	5.3	10	5.2
5) Population (1982) (in millions)	232	25	56	8	118
6) Percent of population 65 years and older (1981)	11.2	9.7	15.3	16.5	9.3
7) Crude birth rate per 1,000 population (1982)	16	15	13	11	13
8) National per capita income (U.S.$) (1981)	10,094	9,133	8,222	13,146	7,672
9) Physicians per 100,000 population (1980)	192	182	154	204	128
10) Hospital beds per 100,000 population (1980)	629	877	1,136	1,492[d]	1,064

[a] Data from 1978.

[b] Data from 1981.

[c] Data from 1982.

[d] Figure includes nursing home beds.

SOURCES:
1) U.S. data from *Health, United States: 1985* (Washington, DC: U.S. Government Printing Office, December 1985). Canadian data from R. Wilkins and O.B. Adams, "Health Expectancy in Canada, Late 1970s: Demographic, Regional, and Social Dimensions," American Journal of Public Health, vol. 73, No. 9, September 1983, p. 1077. Data for U.K. from "World Health Statistics Annual," 1983, World Health Organization, Geneva, Switzerland. Data for Japan and Sweden from *Health, United States: 1985*, op. cit.
2) U.S. data from *Health, United States: 1985*, op. cit. Canadian data from Wildins and Adams, op. cit. Data for Sweden and U.K. from "World Health Statistics Annual," 1983, op. cit. Japanese data furnished by Ministry of Health and Welfare, Embassy of Japan, Washington, DC.
3) U.S. data from *Health, United States: 1985*, op. cit. Data from Canada, Japan, and Sweden from *Demographic Yearbook, 1982*, United Nations, N.Y. U.K. data from "World Health Statistics Annual," 1983, op. cit.
4) 1982 data for Japan from "Health and Welfare Statistics in Japan," Health and Welfare Statistics Association, Japan, 1985. 1983 data for Sweden from "Fact Sheets on Sweden: The Health Care System in Sweden," The Swedish Institute, FS 761Vpb, Sweden, 1983. U.S. 1983 data is from *Health, United States: 1985*, U.S. DHHS Pub No. 86-1232, 1985. Data from the United Kingdom for 1980 from "International Financial Statistics Yearbook, 1981," International Monetary Fund, 1981. Data for Canada (1982) from the Canadian Embassy, Washington, DC, personal communication, April 1986.
5) *World Development Report*, The World Bank, Washington, DC, 1984.
6) "World Health Statistics Annual," op. cit., 1983 and 1984. Data for the U.S. is from "Social Security Area Population Projections," 1983, U.S. Department of Health and Human Services. SSA Publication No. 11-11535, 1983.
7) *World Development Report*, op. cit.
8) *Statistical Yearbook, 1981*, United Nations, New York, 1983.
9) Estimates from *World Development Report*, op. cit.
10) Data from 1980 World Health Organization Statistics reported in "World Health Systems: Lessons for the United States," report presented by the Chairman of the Select Committee on Aging, U.S. House of Representatives (Washington, DC: U.S. Government Printing Office, 1984).

insurance. The United States, which provides neither comprehensive health insurance nor guaranteed access, has the lowest health status. (See box 3-A for a discussion of the limits of existing U.S. funding programs.) The United Kingdom and Canada, with comprehensive health insurance but varying degrees of access, have life expectancies and infant mortality rates in the intermediate range.

These facts may suggest that health care strategies exist in other countries that are economically preferable to the U.S. model. They may also simply mean that Americans are prepared to sacrifice 5 to 10 years of life in order to enjoy aspects of U.S. culture not enjoyed by other cultures that produce less disease. If nothing else, they suggest that significant changes in the cost and success of the U.S. health care system are possible during the next two decades.

Choices and Consequences

Estimates of the future performance of the Nation's medical system require answers to the following types of questions of health care finance and management:

- Will systems be developed that provide employers of all kinds a greater incentive to provide employees with health programs that include prevention and adequate care?
- Will systems be developed that provide access to high-quality health care for those lacking access to well-managed corporate or government health programs? Will there continue to be large differences in the medical benefits received by people in different income groups?
- Will health-related information available to consumers be improved? Will consumers change their behavior as a result?
- Can the incentive systems of the health industry be changed to give patients and providers similar interests in the support of cost-effective health care that balances prevention, health promotion, and other forms of health care?
- Will medical consensus converge at the lower end of the range of health care utilization (implying at least a 40-percent reduction in hospital costs), or will the lower rates prove to be ill advised?
- Will social policy (and private insurance programs) set standards demanding comparatively large numbers of years saved per dollar spent on health care?

Box 3-A.—Medical Coverage for the Poor

America's lower income groups are poorly served by the health care system:

- Medicaid provides coverage to a decreasing number of the poor. In 1985, Title XIX served only 40 percent of the population with incomes below the poverty line; in 1976, it served 65 percent.[1]
- Many States have not adjusted Aid to Families with Dependent Children (AFDC) income levels to account for inflation. From 1970 to 1984, State AFDC benefit levels for a family of four, in constant dollars, failed to keep up with inflation in all but two States—Wisconsin and California; across the country, the median decline in benefit levels, adjusted for inflation, was 33 percent. A study by the U.S. General Accounting Office estimated that 493,000 families lost their AFDC coverage as a result of changes brought about by the Omnibus Budget Reconciliation Act. In 1981, 1 million families had at least 1 member who needed medical care during the year but did not receive it for financial reasons.[2]
- Among the under-65 population, the percentage that is uninsured grew from 14.4 percent in March 1980 to 16.0 percent in March 1983. Between 1981 and 1982, the number of uninsured adults living with an employed, insured spouse almost doubled. Three-fourths of the 35 to 37 million uninsured are either employed or dependents of employed persons.[3]
- As many as 35 million people (17 percent of the population) were uninsured in 1984, including 12 million persons with income below the poverty level who did not qualify for Medicaid.[4]
- About one-third of all uninsured individuals are under the age of eighteen.[5]

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[1] Jim Sarsgard, Actuary, Division of Medicaid Cost Estimates, Office of the Actuary, Department of Health and Human Services, based on Census Bureau Statistics and the Current Population Survey.

[2] M. E. Lewin, "Financing Care for the Poor and Underinsured: An Overview," in M.E. Lewin (ed.), *The Health Policy Agenda: Some Critical Questions* (Washington, DC: American Enterprise Institute, 1985).

[3] M. E.Lewin and Lawrence Lewin, "Financing Charity Care in an Era of Competition," *Health Affairs*, spring 1987, p. 51.

[4] Jim Sarsgard, op. cit.

[5] Uwe Reinhardt, "Health Insurance for the Nation's Poor," *Health Affairs*, spring 1987, p. 101.

- Will large medical systems such as integrated hospital systems be able to manage significant savings?

Other issues include:

- Will cures be found for major illnesses such as heart disease, cancer, and senile dementia? If so, will they be cheap (i.e., vaccination), or will they require lengthy and expensive treatment? Will acquired immunodeficiency syndrome (AIDS) or a health menace of equivalent proportions impose new burdens on the system?
- Will government support of medical education and medical research be vigorous? Will public and private regulation of the quality of health care prove adequate?

Considering the Possibilities

Any one of the factors listed above could lead to considerable changes in both the cost of national health care and health of the average American. Few of the factors can be predicted simply by looking at trends—many are matters of public and private choice. Table 3-5 explores some alternatives in quantitative terms. It is based on a 1980 survey linking spending on health care to a patient's age and the condition for which treatment was received.[80] The increase in spending shown in table 3-5 assumes that the cost of intervention remains unchanged. Changes result entirely from assumptions about the success of the intervention. The basic assumption of the calculations is that a person whose death has been avoided by an assumed improvement in some kind of treatment (e.g., a cure for cancer) would have the same risk of dying of other kinds of disease in later years as the average person of the same sex and age.

The results of a calculation like the one displayed in table 3-5 can be difficult to interpret since it includes a variety of offsetting factors. The analysis is not intended to provide a precise forecast, but rather to exhibit the striking range of costs and health out-

Table 3-5.—Hypothetical Scenarios for the U.S. Health Care System

Year	Life expectancy (years at birth) Male	Female	Lifetime disability days (1983 = 100) Male	Female	National health care costs (1983 = 100)
1983	70.8	78.0	100	100	100
2005:					
AIDS epidemic[a]	70.7	78.0	126	100	140
1983 mortality rates	70.8	78.0	126	100	133
Half infant mortality[b]	71.8	79.2	91	89	134
Social Security Administration pessimistic scenario[c]	73.1	80.5	125	100	137
No smoking[d]	74.3	81.4	108	85	119
Social Security Administration baseline scenario[c]	75.3	82.9	137	110	142
Cancer cure[e]	75.8	83.0	136	104	135
Modest prevention[f]	76.0	84.2	105	82	116
Cure heart disease[g]	77.0	84.0	148	117	144
Extensive prevention[h]	78.4	84.5	111	88	115
Social Security Administration optimistic scenario[c]	78.6	86.4	156	125	146
Optimistic prevention[i]	78.7	84.8	91	89	135

[a] AIDS (acquired immunodeficiency syndrome) case assumes no change from 1983 mortality patterns except that death from "other causes" increases 21%.
[b] Cuts mortality and morbidity for infant mortality and congenital diseases in half.
[c] Mortality assumptions used by the Office of the Actuary, U.S. Social Security Administration in their forecast of U.S. population growth. See U.S. Social Security Administration, Population Projections 1983; *World Development Report*, The World Bank, Washington, DC, 1984.
[d] Assumes that cigarette smoking is responsible for 15% of heart disease deaths, 32% of cancer deaths, 10% of deaths from vascular disease, 43% of deaths from chronic obstructive lung disease, 16% of deaths from diseases of the digestive system, and 16% of deaths from all other causes.
[e] Cancer mortality and morbidity falls to zero in 1990.
[f] No smoking, 50% reduction in accident rate from lowered alcohol use and seat belts and workplace safety.
[g] Reduces heart disease mortality to zero and heart-related illness by 30% starting in 1990.
[h] Same as (e) except that improved diets are assumed to reduce cancer deaths an additional 67% and deaths from digestive diseases 50%.
[i] Same as (h) only cuts mortality and morbidity for diseases of infancy and congenital diseases in half.
For more details, see U.S. Congress, Office of Technology Assessment, "Health," sector study, 1987; and D. Gillman, "Health Cost Forecasting for the U.S.," working paper prepared for the Office of Technology Assessment, 1985.

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[80] The National Medical Care Utilization and Expenditure Survey, conducted by the National Center for Health Statistics. Corrections for underreporting were made following the suggestions of a study of this data conducted by J.M Anderson and E. Thorn, "Estimates of Aggregate Personal Health Care Expenditures in 1980," ICF, 1985. See D. Gillman, "Documentation on the Population Projection Program (PROPOP)," paper prepared for the Office of Technology Assessment, 1985.

comes possible given a plausible set of assumptions. Total national health care costs hinge on whether comparatively expensive or comparatively inexpensive causes of illness and death are reduced. The costs in the year 2005 depend on the population in that year. This is in part a function of mortality patterns prior to 2005. A comparatively inexpensive "magic bullet" cure for cancer in the year 2000 (the equivalent of a vaccine or penicillin) would reduce costs in 2005, but would increase them in later years because the individuals living longer as a result of the cure would begin to incur other health care costs. The costs are also extremely sensitive to whether the factors that decrease mortality also lead to a corresponding decline in sickness requiring medical attention. The large range of variation in days of disability translate into differences in national health care costs.

Constructing Scenarios

The hypotheses just generated can be combined with assumptions about growth in the intensity of treatment, and from these combinations can be developed scenarios of spending on the Health amenity. In all cases it is assumed that the relationship of government purchases to consumer spending remains the same.The results are summarized in table 3-6. In the 3 percent Trend scenario, these assumptions imply that government purchases of Health as a share of all government purchases rise substantially. The rise is less pronounced in the 3 percent Alternative scenario, following the lower cost "prevent" scenario. However, the share rises 1.5 percent under the Alternative scenario, due to the assumed provision of comprehensive medical care even at low rates of economic growth.

The Trend scenarios are based on an assumption that growth in health care spending will follow 1960-83 patterns, and increase 38 percent faster than total personal consumption expenditures (PCE). This implies that PCE Health expenditures will increase by just over 4 percent annually in the 3 percent growth case, and by about 2.1 percent annually in the 1.5 percent growth scenario.[81]

Table 3-6.—Consumption Scenarios for Health (billions of 1983 dollars)

		2005			
	1983	Trend 3%[a]	Trend 1.5%[b]	ALT 3%[c]	ALT 1.5%[d]
Household spending ...	268	650	420	500	418
Government spending ...	60	147	95	113	94
Total	328	797	515	613	512
Percent share of GNP	9.6	12.2	10.9	9.4	10.9

ABBREVIATIONS: ALT = alternative scenarios, GNP = gross national product

[a] Assumes U.S. Social Security Administration (SSA) baseline scenario hypotheses illustrated in table 3-5, and per-capita intensity increases at 2.5%/year—roughly half the average rate of the 1972-86 period.

[b] SSA "pessimistic" scenario from table 3-5, and an intensity growth of 0.6% per year.

[c] "Extensive prevention" case from table 3-5, and intensity grows at 1/6 historic rates.

[d] "Modest prevention" case from table 3-5, and intensity grows at 1/6 historic rates.

SOURCE: Office of Technology Assessment, 1988.

The Alternative scenarios are based on the "modest" and "extensive" "prevention" scenarios shown in table 3-5, and on an assumption that health care is more equitably allocated among income groups. It is assumed that the rate of growth in intensity of care (in this case measured in constant dollar spending per treatment) is approximately one-sixth the 1972-86 rates because a better match between health care spending and outcome is achieved.

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[81] This expenditure trajectory is consistent with projections for 1990; Ross H. Arnett III, et al., "Health Spending Trends in the 1980s: Adjusting to Financial Incentives," *Health Care Financing Review*, vol. 6, No. 3, spring 1985.

HOUSING

The Housing Recipe

Unlike health, it is difficult to develop statistics giving an unambiguous measure of housing as an amenity.[82] For most, the "American Dream" house apparently remains a detached residence, with pleasant grounds, security, and a comfortable interior. A general definition of "quality" in housing includes minimal maintenance (e.g., plumbing that works, roofs that don't leak, and windows that open), good lighting, and a heating and cooling system that provides desired levels of comfort. Recent discoveries about the quality of indoor air are now making clean and safe air a part of "quality" in homes, as well. A good location is also an important, if somewhat ambiguous concept. Definitions of desirable locations include assets such as physical attractiveness, safety, and good public schools; and convenient access to jobs, shopping, and recreational areas. This is becoming an increasingly challenging problem as both husbands and wives commute to work.

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[82] Housing expenses are defined to include all spending on structures, home furnishings, the energy needed to maintain comfortable temperatures, adequate lighting, hot water, cooking facilities, and related needs such as mortgage financing. Energy includes payment for gas, oil, electricity, and other fuels. "Other" includes spending for home furnishings, cookware, water and sewer, and the other products associated with household operation. It does not include products associated with personal business or entertainment such as telephone, stationery, and home electronics. Spending for new housing units is not counted as a "personal consumption expenditure" in the National Income and Product Accounts, but is instead counted as a kind of savings. This distinction between housing as an amenity and housing as an investment is a vexing problem of definition. For the purposes of the analysis presented in this document, spending on home equity is included as a part of spending for the housing amenity.

Changes in tastes and demographics have a powerful effect on demand for housing. For example, the growth of the elderly population and increases in home health care place new demands on housing for people with mobility limitations. Nearly 40 percent of all persons aged 65 to 74 have some activity limitation, and 63.2 percent of individuals over the age of 74 have some limitation.[83] More than five percent of the total population are blind or visually handicapped, 7.4 percent are deaf or hearing impaired, 3.2 percent have some form of lower extremity impairment, and 1.2 percent have upper extremity impairment.[84]

The growth of single-person households and the "other" household categories translates into complex patterns of demand for housing. The decline in leisure time caused by an increase in work-related activities translates not only into demands for shorter, more "intense" vacations (see discussion of recreation and leisure later in this chapter), but also into greater demand for recreational amenities within a house.[85] New technologies are redefining the definition of interior amenity. Home entertainment involves an increasingly elaborate and powerful array of video and sound equipment, for example. Home offices are becoming common for professionals and there has been a small (but limited) increase in home-based work. Broadband communications wiring in houses is likely to be as common as telephone wiring today.

The continuing mobility of Americans means that for many people housing is not a permanent investment.[86] Many make purchases with no intention of sinking deep roots in a community. In 1985, only 58 percent of Americans lived in their 1980 residence. Movers were about equally divided between those moving to a new house in the same county, many of whom were undoubtedly "trading up" to improved residences,[87] and those moving out of the county. While two-thirds of the residents of the northeast remained in their 1980 homes, in the west movers outnumbered nonmovers. Nearly one-quarter of the people living in the west moved outside their county and 15 percent moved from another State or another country. Two-thirds of all young adults (age 20 to 34) moved during the first half of the 1980s; nearly one-third moved out of the county. While many elderly persons may move from their residences to retirement communities, 84 percent did not move at all and only 7 percent moved out of the county where they lived in 1980 (see table 3-7).[88]

Table 3-7.—Mobility of the U.S. Population

Asked in 1985 where they lived in 1980, the responses were as follows:

	Now live in the same unit they occupied in 1980	Lived in a different unit in same county in 1980	Lived in another county or abroad in 1980
Total	**58.3**	**22.1**	**19.6**
By age:			
Age 5-19	57.0	24.1	18.9
Age 20-34	35.3	33.5	31.2
Age 35-64	68.9	16.2	15.0
Age 65+	83.5	9.2	7.3
By 1985 location:			
Northeast	66.9	18.8	14.3
Midwest	60.9	22.9	16.2
South	56.0	21.5	22.5
West	49.6	26.0	24.4

NOTE: Does not include members of the armed forces except those living off post or with their families on post.

SOURCE: U.S. Department of Commerce, Bureau of Census, CPS Series P-20, 1985.

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[83] U.S Congress, Office of Technology Assessment, *Technology and Aging in America*, OTA-BA-264 (Washington, DC: U.S. Government Printing Office, June 1985), pp. 291-292.

[84] U.S Congress, Office of Technology Assessment, *Technology and Handicapped People*, OTA-H-179 (Washington, DC: U.S. Government Printing Office, May 1982), p. 22.

[85] C. Vogel, "Clustered for Leisure: The Changing Home," *New York Times Magazine*, June 28, 1987, p. 13.

[86] See the last section of ch. 5 for a discussion of the ways changing economic structure are moving jobs around urban areas and among regions.

[87] H.J. Brown and J. Yinger, *Homeownership and Housing Affordability in the United States: 1963-1985* (Cambridge, MA: Joint Center for Housing Studies, 1986).

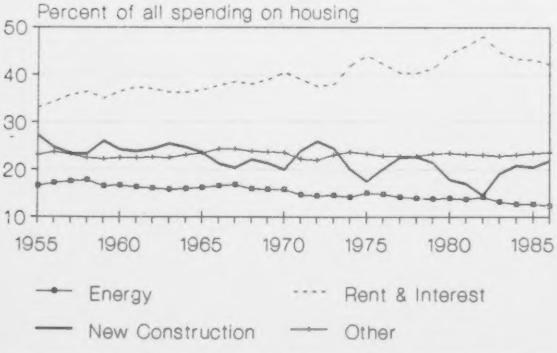
[88] U.S. Bureau of Census, Current Population Survey, Series P-20, 1985.

While much of the discussion in this chapter focuses on the ability of new production technology to tailor products to niche markets and changing tastes, housing will be an exception. The mobility of the U.S. population means that housing is seldom tailored to the tastes of individuals but rather to a homogeneous "resale market."

The fact that homeowning has been a lucrative form of savings for many makes it difficult to link spending patterns with levels of amenity achieved. Programs designed to make housing affordable to the middle class have had the effect of making it an attractive investment. Housing investments are unique because the owner is free from tax on the effective income enjoyed by renting a property to himself. Many households are, as a result, "overhoused," in the sense that their spending on housing exceeds the spending that would have occurred in the absence of this investment incentive.[89] Equity in homes represents 64 percent of the median net worth of homeowners today.[90]

Since 1950 there has been a significant increase in the share of spending for housing that goes to financial institutions, landlords, and insurance companies (see figure 3-5). In contrast, the fraction that goes to an increase in net equity in housing (the "new construction" portion shown in figure 3-5), has fallen steadily since 1950, and has become much more cyclical. The increase in other housing costs has been so great that they make the dramatic increase in energy prices during the 1970s all but invisible. Lower prices for home furnishings ("other" in the figure), and perhaps some saturation in demand for such goods, have resulted in a steady but slow decline in the fraction of spending devoted to this area.

Figure 3-5.-Spending on Housing by Major Category



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 2.5.

A variety of costs are not directly reflected in the statistics of figure 3-5. For example, residential electricity and gas customers often do not pay their real share of costs because regulatory commissions elect to subsidize residences by charging higher rates to commercial and industrial customers. Few rates reflect the marginal cost of producing energy from new sources. Water and sewerage lead to enormous costs which are typically hidden because much of the cost is provided through the tax base rather than through direct user charges. A survey in Irvine, CA, conducted by its "funding task force," found that the cost of providing streets, parks, schools, flood control, civic and performing arts buildings, and libraries was between $16,500 and $23,800 per dwelling.

Trends in U.S. Housing Quality and Affordability

There is reason to believe that on average American housing has improved in virtually all of the areas mentioned. The average housing unit is larger than it was a decade ago even though household sizes are smaller.[91] The number of units with more than one person per room fell from 3.8 percent of all units to 2.6 percent.[92] There has been a significant increase in the number of units equipped with such amenities as air conditioning, garages, and full city water and plumbing.[93] Correspondingly, a smaller fraction of Americans live in units with major defects.[94] Moreover, the statistics of chapter 2 indicated that these improvements have been achieved without an increase in the average levels of spending for housing as a fraction of overall consumer spending.

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[89] U.S. Congress, Congressional Research Service, "Housing Programs Affecting the Elderly: A History and Alternatives for the Future," Report No. 82-119E, Washington, DC, June 1982.

[90] U.S. Bureau of the Census, Current Population Reports, Series P-70, No. 7.

[91] In 1968, the median size of new privately owned single-family homes completed in the United States was 1,385 square feet. In 1980, it was 1,595 sq. ft., and in 1985, it was 1,785 sq. ft. See *Statistical Abstract of the United States 1987*, op. cit., footnote 39, p. 706.

[92] Irendia Irby, *Housing Problems in the United States*, U.S. Department of Housing and Urban Development, Division of Housing and Demographic Analysis (Washington, DC: U.S. Government Printing Office, June 1985).

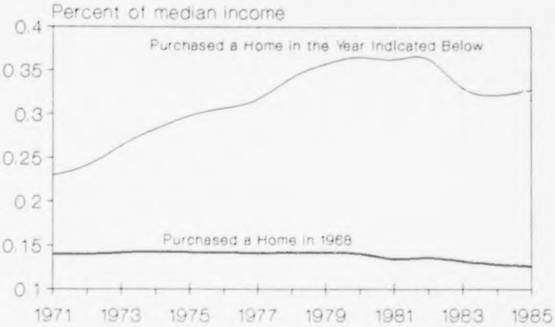
[93] *Statistical Abstract of the United States 1987*, op. cit., footnote 39, p. 710.

Any problems with American housing lie not with the averages but with the difficulties encountered by specific groups. Young families, one-wage earner households, minorities, and individuals trying to find housing in areas of rapidly expanding employment all often face painful decisions about housing. They are forced to rent rather than buy, and may commute longer distances or make other sacrifices in order to find affordable housing. Many still pay a very high fraction of their income for housing. There is a very real danger that recent trends will result in a situation where there will be two sharply divided household classes in America—those fortunate enough to have purchased housing in the 1970s (or inherited a house from them) and all others.

In 1983, homeowners had an average net worth of $97,239, a net worth 920 percent higher than the net worth of renters.[95] This could indicate that only the poorest Americans do not buy housing. It could also indicate that house ownership has been an extremely effective way of increasing individual net worth in the past few decades. Whatever the reason, the 64 percent of the population which owns housing clearly has a strong vested interest in seeing the value of their investments increase, and this makes them a powerful lobby against any measure that would have the effect of lowering the real cost of housing.

Figure 3-6 tells some of the story. In spite of some relief from the extraordinary peak in 1982 due to lowered interest rates, the cost of purchasing and operating a new home has grown spectacularly when measured as a fraction of median income, reaching 32 percent of median household income in 1985. This cost is clearly out of reach for many demographic groups. Families with only a single wage earner face the most pressing difficulties except where the single earner is in a high-income occupation (e.g., a manager or professional; see table 3-8). A new home is far beyond the reach of most female-headed households.

Figure 3-6.-Cost of Home Purchasing for New Homeowners and Families Who Purchased a Home in 1968



How To Read This Figure: In 1985, a family earning the median income that purchased a home in 1968 would be paying about 13 percent of its income for housing (limited here to mortgage payments, maintenance, and energy). The same family would be paying about 33% of its income for housing if it purchased a house in 1985. Some of the difference results from closing and costs associated with new home purchasing. One-third of these costs are assumed to be paid in the first year of home ownership.

SOURCE: H. James Brown and John Yinger, "Home Ownership and Housing Affordability in the United States: 1963-1985," report for the Joint Center for Housing Studies of the Massachusetts Institute of Technology and Harvard University, Cambridge, MA, 1986.

Table 3-8.—After Tax Cash Costs of a New Home Purchased in 1985 (as a percent of annual income[a])

	Percent
By family type:	
Married couples	30
Both husband and wife work	26
One earner families	46
Single woman household (one earner)	75
By occupation for single earner:	
Precision production, craft, and repair	41
Administrative support including clerical	54
Executive, administrators, and managerial	31

[a] Tax rate not adjusted for income or family type. Assumes 24% marginal tax rate and $3,400 deduction. This error underestimates the real after tax costs of low-income households.

SOURCES: Housing costs taken from "Home Ownership and Housing Affordability in the United States: 1963-1985," Joint Center for Housing Studies of the Massachusetts Institute of Technology and Harvard University, Cambridge, MA, 1986. Income data from U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, 1986.

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[94] Between 1975 and 1985, the percentage of all units defined to be "inadequate" (e.g., they lacked or shared some or all plumbing, lacked or shared some or all kitchen facilities, were inadequately maintained, or had public hall deficiencies, inadequate heating equipment, electrical defects, or inadequate or broken sewer) fell from 10.6 percent to 8.9 percent. Those judged to be "severely inadequate" fell from 4.3 percent to 2.6 percent. See Irendia Irby, op. cit., footnote 92.

[95] *Statistical Abstract of the United States 1987*, op. cit., footnote 39, p. 451.

How can the fraction of income spent on housing remain constant (again see figure 3-5) while housing stretches the resources of the median household? How can the increase in the size of new housing units be consistent with the shrinking fraction of the population able to afford housing? The answer is a growing gap between haves and have nots in housing. Figure 3-6 compares the cost burden of a new homebuyer with the price paid by a household still living in a home purchased in 1968. Housing actually consumes a declining share of the income of the 1968 purchaser in spite of the rapid increase in energy costs that has occurred since 1968.

Accounting for Changing Costs

Three factors account for the sharp rise in housing costs documented in figure 3-6:

1. increasing land costs near areas of employment growth (spurred in part by restrictive zoning and other local policies for limiting growth),[96]
2. increased cost of financing for housing (resulting directly from deregulation in thrift institutions), and
3. rising energy costs.

While there has been some increase in the cost of construction materials and labor, and some decline in the productivity of labor in residential construction, these do not appear to have had a dominant effect on overall housing costs. Between 1970 and 1980, the cost of a new single-family home actually fell 16 percent in constant dollars while the cost of the materials and labor in the home fell 30 to 40 percent. During the same period the cost of financing increased nearly 80 percent.[97] Given that many developers make most of their money from financing and land development, it is easy to see how they are likely to add amenities and a few hundred square feet to a property if this will give them a competitive edge.

Between 1975 and 1985, the real cost of a 10,000 square foot lot of improved land increased in price by 66 percent; the price of an unimproved lot increased by 78 percent. Prices were particularly high in areas of high growth like California and Florida. While a 10,000 square foot lot cost $2,500 in Chattanooga in 1980, it cost $187,000 in San Jose, CA.[98] Some of this was the result of scarcity in growing areas, some from speculation based on high inflation rates, and some resulted from extensive growth in restrictive zoning.[99] Several parts of the San Francisco Bay area have instituted regulations that have increased housing prices by at least 20 to 30 percent.[100]

Many other cities have taken measures to limit growth, including Montgomery County, MD and Fairfax County, VA in the Washington, DC area; and Fairfield County, CT, and White Plains, NY in the New York City area. Fairfield County and many other areas have adopted ordinances designed to limit both residential and commercial construction. Zoning in over one-third of 75 municipalities covered in a 1976 New Jersey survey required minimum lot sizes greater than 1 acre. Most communities squeeze "manufactured housing" into disadvantaged locations; many do not permit such units at all.[101] Apart from driving up property values, one curious feature of these policies is to decrease population density. This results from the fact that housing density remains fixed in heavily regulated areas while household size declines.[102]

The rapid increase in financing costs was due to a combination of general inflation with regulatory changes in the banking industry undertaken when short-term rates rose rapidly during the 1970s. Investors turned increasingly to money market and other instruments instead of traditional "thrift institutions." In effect, homebuyers are competing for money with other borrowers throughout the economy.[103]

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[96] R. Babcock, *The Zoning Game* (Madison, WI: The University of Wisconsin, 1964).

[97] "Report of the President's Commission on Housing," Washington, DC, 1982. Figures cited converted to constant dollars using the consumer price index.

[98] *Residential Land Price Inflation Survey* (Washington, DC: The Urban Land Institute, 1986).

[99] Robert Cervero, "Jobs-Housing Imbalances in Suburban Employment Markets: An Empirical Investigation," Department of City and Regional Planning, University of California at Berkeley, May 1987.

[100] D. Dowall, *The Suburban Squeeze* (Berkeley, CA: University of California, 1985).

[101] See S. Seidel, *Housing Costs and Regulations: Confronting the Regulatory Maze* (New Brunswick, NJ: Center for Urban Policy Research, 1978), p. 174; and the "Report of the President's Commission on Housing," op. cit., footnote 97.

[102] M. Gellen, *Accessory Apartments in Singe-Family Housing* (Piscataway, NJ: Center for Urban Policy Research, 1985); D. Schoup, *Curb Parking as a Commons Problem* (Los Angeles, CA: University of California, Graduate School of Architecture and Urban Planning, 1983).

The 1986 changes in tax law affect housing costs in complex ways.[104] The number of new rental units is likely to continue the decline that began before the law was changed, partially offset by "non-new" units converted from nonresidential use.

Reacting to Higher Costs

Buyers reacted to the rising cost of housing in a variety of ways. Lending rules were stretched to permit buyers to take higher risks. But there is plainly a limit. The increased cost of housing has led to a decline in ownership rates, particularly for younger families most likely to need new housing (see table 3-9). The need for mobility on the part of younger individuals also contributes to their housing dilemma.

Declines in home ownership are naturally matched by increases in the number of individuals renting. In 1987, 55 percent of young adults (aged 25 to 34) lived in rental units—up from 48 percent in 1974. In 1983, 62.5 percent of female single parents were in rental units; the figure was 88.7 percent if they had a child younger than 6. Both statistics represent an increase from 1974. Renters avoided the high cost of home purchasing but were still affected by growing housing costs. In 1987, contract rents averaged 25.5 percent of the income of renting families, up from 20.5 percent in 1974. In 1983, 55 percent of households earning less than 50 percent of the median household income paid more than 30 percent (up from 48 percent in 1974).[105]

Table 3-9.—Household Ownership by Age, 1980-87

Age	Percentage owning their own homes 1987	Increase/decrease in percent 1980-87
Under 25	16.1	−5.2
25-29	35.9	−7.4
30-34	53.2	−7.9
35-39	63.8	−7.0
40-44	70.6	−3.6
45-54	75.8	−1.9
55-64	80.8	1.5
65-74	78.1	2.9
Over 75	70.7	2.9
Total	64.0	−1.6

SOURCE: W.C. Apgar, Jr. and H.J. Brown, "The State of the Nation's Housing 1988," Joint Center for Housing Studies of Harvard University, Cambridge, MA, 1988, p. 12.

Some rentors have accepted a decline in housing quality. While the percentage of rented units with defects has declined, the 19-percent increase in the total number of rented units meant that there was a 7-percent increase in the number of families living in inadequate rented housing. Single adults and individuals between the age of 25 and 35 were most likely to live in inadequate rental units. One index of housing inadequacy indicates that inadequate housing declined from 15.5 to 12.8 percent between 1974 and 1983.[106]

Other responses to increased housing costs include living with relatives, forming households of unrelated individuals, or taking in borders. Between 1980 and 1986, the number of total U.S. households increased 9.5 percent. During the same period, the number of households comprised of related subfamilies increased 96 percent, unrelated subfamilies increased 40.3 percent, and unrelated individuals increased 19.2 percent. Single females with children clearly faced the greatest problem finding housing; the number of mother-child families living with relatives increased 173 percent between 1980 and 1986.[107]

For those on the bottom of the ladder, housing has become a disaster. The Nation's mayors report that demand for emergency shelter increased by an average of 20 percent in 25 major U.S. cities during 1986.[108]

While changes in cost burdens are relatively visible, other changes in housing quality are more difficult to measure. There is compelling evidence that other amenities have been sacrificed in order to keep housing costs acceptable. One traditional cure for high land prices is making a trade-off between commuting time and housing costs in suburban and exurban regions.[109] The trade-off has become much more complex as jobs begin to drift toward suburban locations and as husband and wife must compromise on commuting time. Twenty percent of all trips to work are now from suburbs into central cities. The share of people who both live and work in suburbs has risen from 30.5 percent in 1960 to 41.9 percent in 1980. It is 60 percent in greater Boston, Detroit, St. Louis, and Pittsburgh.[110]

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[103] A. Downes, *The Revolution in Real Estate Finance* (Washington, DC: The Brookings Institution, 1985).

[104] "Description of Provisions of the Tax Reform Act of 1986 Relating to Housing," paper prepared by the National Association of Homebuilders, Government Affairs Division, September 1986.

[105] I. Irby, op. cit., footnote 92.

[106] H.J. Brown and J. Yinger, op. cit., footnote 87.

[107] Current Population Reports, op. cit., footnote 88, No. 412.

[108] "The Continued Growth of Hunger, Homelessness and Poverty in America's Cities: 1986," The U.S. Conference of Mayors, Washington DC, 1986.

While middle class families may have paid a price to combine job access and housing amenity, low income groups, particularly blacks, paid an even greater price since their mobility was highly constrained. Ironically, subsidized low income housing may have the effect of anchoring low income groups to declining areas.[111]

Zoning, housing costs, and multiple-worker families mean that a shrinking fraction of individuals can live in the same community where they work. Only half of the people in the San Francisco area work in the community where they live. There were only 35 jobs for every 100 people housed in "bedroom" communities like Daly City. San Jose, Fremont, Concord, and Alameda averaged 50 to 67 jobs per 100 residents. In other areas, high property costs make residence virtually impossible for middle income families. As a result, there were 203 jobs for every 100 residents of Palo Alto, 172 for every 100 residents in Santa Clara ("Silicon Valley"), 150 per 100 for Sunnyvale, and 132 per 100 for Mountainview.[112]

The effect of sprawl, coupled with the separation of work and housing, has meant that commuting time has increased for many. While there is considerable variation, travel distance has increased while travel time has reportedly declined (implying an increase in commuting speed). Curiously, it is the upper income managers who have elected to travel further to achieve their housing amenity (see table 3-10), in spite of the fact that their time is presumably more valuable. Also, since men commute longer distances than women it appears that women may be taking jobs closer to home, possibly sacrificing income in order to combine lives as a homemaker and paid employee.

Construction Technology

New building technologies (discussed in ch. 6) and new materials can reduce the cost and improve the quality of housing. Factory construction can permit reliability and brand-name guarantees for major building components and entire structures because sections are produced consistently under factory conditions. And where markets exist, it should be possible for customers to design houses to their unique needs.[113] It may even be possible to construct homes from modular units that permit relatively easy changes of floor plans. This possibility might permit more flexibility in the design of structures that are purchased both as an amenity and for their po-

Table 3-10.—Commuting Distances and Times

	1983			1969
	Men	Women	Total	Total
Trip length (miles)	11.2	8.3	9.9	9.7
Trip time (minutes)	21.6	18.8	20.4	23.1
Average speed (mph)	31.1	26.5	29.1	25.2

By occupation:

	Distance (miles)		Time (minutes)	
	Commute 1983	Increase from 1977 to 1983	Commute 1983	Increase from 1977 to 1983
Professionals	9.8	−0.9	20.0	−1.8
Managers	12.5	2.4	24.2	3.5
Clerks	9.1	1.0	19.8	0.8
Laborers	11.8	0.3	22.8	1.0
Unskilled	11.0	1.0	21.4	1.1
Services	6.7	0.2	16.1	0.0
Total	9.9	0.6	20.4	0.6

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *1983-1984 Nationwide Personal Transportation Study*, volume I, Washington, DC, August 1986, pp. 7-6 to 7-10.

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[109] For more on this subject, see W. Alonso, *Location and Land Use* (Cambridge, MA: Harvard University Press, 1964); J.D. Carroll, "The Relation of Home to Work Places and the Spatial Patterns of Cities," *Social Forces*, vol. 30, No. 1052, pp. 271-282; H.J. Brown, "Changes in Workplace and Residential Locations," *Journal of the American Institute of Planners*, No. 41, 1975, pp. 32-39; W.A.V. Clark and J.E. Burt, "The Impact of Workplace on Residential Location," *Annals of the Association of American Geographers*, vol. 70, No. 1, Mar. 1980, pp. 59-67; L. Orr, *Income, Employment and Urban Residential Location* (New York, NY: Academic Press, 1975); and J. Quiggley and D. Weinberg, "Intraurban Residential Mobility: A Review and Synthesis," *International Regional Science Review*, vol. 2, No. 1, Fall 1977, pp. 41-66.

[110] Robert Cervero, op. cit., footnote 99.

[111] J.D. Kasarda and J. Friedrichs, "Comparative Demographic Employment Mismatches in U.S. and West German Cities," *Research in the Sociology of Work*, No. 3, 1985, pp. 1-30.

[112] R. Cervero, 1987, op. cit., footnote 99.

[113] U.S. Congress, Office of Technology Assessment, *Technology, Trade and the U.S. Residential Construction Industry—Special Report*, OTA-TET-315 (Washington, DC: U.S. Government Printing Office, September 1986).

tential resale value. A variety of gadgets ranging from microwave ovens to improved security systems are available and may add to the value of housing in the future.

New materials, clever use of microelectronic control technologies, and application of competent architectural and engineering in housing design are becoming more common and can reduce energy consumption in homes by factors of two or more. The efficiency of most home appliances can be more than doubled using technology already on the market or under advanced development (see table 3-11). Advances in lighting technology permit graceful integration of day lighting and artificial lighting, better color quality and lack of flicker with high frequency fluorescents, and 200- to 500-percent reduction in energy use by lighting.[114] Even the window is undergoing radical changes in design. It is possible to develop windows with thermal insulation equivalent to 3 inches of fiberglass.[115] Other designs envision windows whose transparency can be altered under direct control, to let solar energy pass in the winter, and to reflect heat in the summer.

The combination of enlightened energy pricing policy with new communications technologies can also help. A 200-house experiment in Roswell, Georgia, uses new "packet switching" technology, along with a small computer in each house, to run air conditioning in a way that minimizes energy costs. The customer simply selects the room temperature desired when electricity rates reach different levels; she may decide, for example, that during the 4 hours a day when prices reach 25 cents/kWh, temperatures should remain at 85 degrees, but during the long periods when electricity costs 2 cents/kWh, temperatures of 65 degrees are preferable. The thermostat adjusts automatically, using signals received through standard telephone lines. The customer is free to override the utility setting at any time, but must pay the going rate for electricity for the privilege. The system saves the utility enough for it to finance the full cost of the system.

A number of studies have tried to determine the number of these technologies likely to make economic sense given perfectly rational decisionmaking by consumers, and the probable investments that will be made under markets likely to exist in the

Table 3-11.—Energy Consumption and Conservation Potential With Residential Appliances

			(KWh/yr or therms/yr)			
	Primary energy use (Q)[a]	Fraction of residential total (%)	1985 stock UEC[b]	1985 new UEC[c]	1985 best UEC[d]	Advanced technology for 1990s[e]
Refrigerator	1.17	7.1	1,500	1,100	750	200-400
Freezer	0.44	2.7	1,100	800	500	150-250
Electric space heating	1.58	9.6	—	—	—	—
Central air conditioning	1.47	9.0	3,600	2,900	1,800	900-1,200
Room air conditioning	0.38	2.3	900	750	500	300-400
Electric water heating	1.35	8.2	4,000	3,500	1600	1,000-1,500
Electric range	0.54	3.3	800	750	700	400-500
Electric clothes dryer	0.45	2.7	1,000	900	800	250-500
Lighting	1.00	6.1	1,000	1,000	650	350-500
Electric other	0.87	5.3	—	—	—	—
Gas space heating	3.36	20.5	730	620	500	300-500
Gas water heating	0.85	5.2	270	250	200	100-150
Gas range	0.31	1.9	70	50	40	25-30
Gas clothes dryer	0.07	0.4	50	40	35	30-35
Gas other	0.41	2.5	—	—	—	—
Total	14.25	86.8				

NOTES:
[a] Applies to 1980.
[b] Unit energy consumption per installation in the 1985 housing stock.
[c] Unit energy consumption for the typical model sold in 1985.
[d] Unit energy consumption for the best available model sold in 1985.
[e] Unit energy consumption possible in new models by the mid-1990s if further cost-effective advances in energy efficiency are made.

SOURCE: Howard Geller, American Council for an Energy-Efficient Economy, January 1986.

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[114] S. Berman, "Energy and Lighting," D. Hafemeister, H. Kelly and B. Levi (eds.), *Energy Sources: Conservation and Renewables* (New York, NY: American Institute of Physics, 1985).

[115] S. Selkowitz, "Window Performance and Building Energy Use: Some Technical Options for Increasing Energy Efficiency," D. Hafemeister, et al., op. cit., footnote 114.

United States during the next two decades.[116] While techniques differ, all show the potential for reducing energy use in housing by large factors. Studies conducted in 1987 provide an example. A recent study conducted by the State of Michigan indicated that residential electricity use could be cut in half by the year 2005 even accounting for expected growth in the housing stock.[117] An analysis of the technical potential of housing design and equipment available on the U.S. market (and the international market) in 1982 suggested that energy use could be one-fifth of the energy used by an average U.S. house in 1980.[118]

Choices and Consequences

Housing costs in the future will hinge critically on the following factors:

- policy affecting speculation in real estate (principally tax policy);
- changes in the geography of economic development, which either encourage geographic concentration (thereby increasing competition for scarce land resources) or result in greater decentralization;
- policy affecting the cost of mortgage financing;
- technical improvements in structures that reduce maintenance and operating costs (principally energy costs);
- policy affecting the housing available for those lacking adequate income; and
- technical improvements in the construction process that reduce construction costs (improvements that could be made more rapid by increased investment in research).

It is impossible to adequately reflect all of these variables in the scenarios selected. An attempt has been made to show what might happen to aggregate demand if no major changes are made in the way Americans invest in housing, and what might happen if policies succeed in arresting the rapid growth in spending in this area. The Trend scenarios, shown in table 3-12,[119] are based on the extrapolation techniques described in chapter 2, which link spending to demographic factors, prices, and income. Independent estimates were made for household utilities to incorporate improvements in efficiency (see

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[116] J.H. Gibbons and W.U. Chandler, *Energy: The Conservation Revolution* (New York, NY: Plenum Press, 1981); Solar Energy Research Institute, *A New Prosperity, Building a Sustainable Energy Future* (Andover, MA: Brickhouse, 1981); M.H. Ross and R.H. Williams, *Our Energy: Regaining Control* (New York, NY: McGraw Hill, 1980); National Audubon Society, *The Audubon Energy Plan 1984* (New York, NY: National Audubon Society, 1984); A. Meyer, J. Wright, and A.H. Rosenfeld, *Supplying Energy Through Greater Efficiency* (Berkeley, CA: University of California Press, 1983); E. Hirst, et al., *Energy Efficiency in Buildings: Progress & Promise* (Washington, DC: American Council for and Energy Efficient Economy, 1986); J. Goldenberg, et al., *Energy for Development* (Washington, DC: World Resources Institute, 1987).

[117] State of Michigan, "Michigan Energy Options Study," 1987. The study defined "technical potential" to be investments that competed with the short-run marginal costs of existing Michigan electric generation—3.27 cents per kWh—assuming a 3 percent discount rate on incremental capital. The reductions consisted entirely of improved efficiency in air conditioning, lighting, water and space heating equipment, refrigerators and freezers.

[118] Goldenberg, et al., op. cit., footnote 116, p. 59.

[119] Three components of household expenditures are distinguished: 1) rents, which includes not only rents paid but also imputed rents received by owner-occupiers; 2) household operations, which include such items as insurance, furnishings, and appliances; and 3) utilities, which include expenditures on energy and water.

Table 3-12.—Consumption Scenarios for Housing (billions of 1983 dollars)

		2005			
	1983	Trend 3%	Trend 1.5%	ALT 3%	ALT 1.5%
Mortgages & rents[a]	331	587[b]	465[b]	565[c]	429[d]
Household operations[e]	139	307[b]	221[b]	302[f]	201[f]
Utilities[g]	111	164	138	95	80
All PCE housing	581	1,058	824	962	710
Residential structures[h]	152	224	202	224	202
Government	14	26	19	26[e]	19[e]
Total	747	1,336	1,063	1,240	949
Percent share of GNP	21.9	20.5	22.5	19.0	20.1

ABBREVIATIONS: PCE = personal consumption expenditure, ALT = alternative scenario, GNP = gross national product

[a] Does not include increase in housing equity. Real increases in total U.S. housing appears in the row labeled "residential structures".

[b] Calculated using extrapolative techniques described in ch. 2.

[c] Assumes that the growth in mortgages and rents as a fraction of all consumption can be reversed and the ratio of spending in this category to total PCE spending falls to 1970 levels.

[d] Same as (c) except that the ratio remains frozen at 1983 levels.

[e] Includes maintenance services and commodities, tenant's insurance, house furnishings, and appliances.

[f] Same as spending in the Trend cases with an increase for assumed additional spending for high efficiency appliances (see table 3-13).

[g] Utilities include natural gas, electricity, household fuels, and water and sewer.

[h] See discussion of spending for gross private fixed investment.

SOURCE: Office of Technology Assessment, 1987.

table 3-13). The Trend projections for energy use are based on a U.S. Department of Energy forecast.[120] The Alternative scenarios assume rapid adoption of technology in building design and appliance design.

Table 3-13.—Consumption Scenarios for Household Utilities

		2005			
	1983	Trend 3%	Trend 1.5%	ALT 3%	ALT 1.5%
Electricity	51	87^a	69^b	44^e	36^f
Natural Gas	29	26^a	26^c	14^e	11^f
Other Fuels	18	26^a	18^c	14^e	8^f
Water & Sewer	13	25^d	23^d	25^d	25^d
Total	111	164	136	97	81

ABBREVIATIONS: ALT = alternative scenario

[a] Based on *National Energy Policy Plan Projections to 2010*, U.S. Department of Energy (DOE), Washington, DC, 1985. Midrange forecast for the year 2005 increased to reflect the higher GNP growth rates used in the 3% Trend scenario. Electricity consumption was increased by 3% to allow for an assumed increase in the size of housing units and an increase in appliance purchases and fuel switching.

[b] 1983 consumption increased in proportion to 2005/1983 increase in consumer units. Electric use per household assumed to decline by 8% as the result of efficiency improvements (far below optimal levels given available technology). Electricity use increases because of an assumed shift from "other fuels." See next note.

[c] 1983 natural gas and "other fuel" use increased by 2005/1983 increase in number of consumer units. No efficiency improvements assumed. 25% of "other fuel" use shifted to electricity.

[d] Projected using CES consumption data (see ch. 2).

[e] 1983 consumption scaled by growth in consumer units. Efficiency improvements computed separately for units in 2005 that were standing in 1983 and units built between 1983 and 2005. The proportion of new and old units is calculated using the assumption that 1.5% of the 1983 stock is removed annually (following recent trends). For existing units, it is assumed that fuel use per unit can be reduced by 35% (primarily through appliance replacement). A combination of improved construction and better appliances is assumed to reduce consumption per new unit by 50%.

[f] Same as (e) except that new units are assumed to have consumption reduced to .3 average 1983 levels and existing units 0.58. It is further assumed that 25% of the "other fuel" consumption is shifted to electricic demand with a net improvement of 0.75.

SOURCE: Office of Technology Assessment, 1987.

TRANSPORTATION

America's need for transportation is as diverse as the U.S. population. There can be no objective measures of progress in transportation, but most Americans are likely to agree that a successful system is one that:

- provides as much freedom of movement as possible—allowing individuals to go where they want, when they want, at the lowest possible cost in time and money;
- provides mobility to the widest possible range of individuals—including the young, the elderly, and the physically handicapped;
- enables efficient supply of the varied goods and services consumed by households;
- increases the number of attractive areas for locating homes and businesses, thereby reducing pressures to increase the price of scarce land while increasing access to needed outdoor recreation areas; and
- has few unattractive "externalities," such as making the Nation vulnerable to foreign oil suppliers, degrading air quality, contributing to deaths and injuries, or creating unattractive landscapes.

For three generations, American criteria for quality transportation have translated into a love affair with the automobile. In 1983, 94 percent of all personal spending for transportation and 87 percent of all government spending for transportation was spent on automobile travel and highways. About 77 percent of all trips (and person-miles) are taken in automobiles or light trucks.[121] An ability to drive is as necessary for a comfortable life in most suburban areas as an ability to walk. Women, particularly those needing to work, are now comparable to men in the proportion of licensed drivers. While only 74 percent of working women had licenses in 1969, 91 percent had them in 1983 (see table 3-14).

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[120] U.S. Department of Energy, *National Energy Policy Plan Projection 2010* (Washington, DC: U.S. Government Printing Office, 1985).

The spending estimates actually underestimate the real cost of automobiles, if only because the opportunity cost of extensive "free" parking spaces provided by businesses is not counted in this total; nor are the costs of garages that are included in home prices. In some areas, these parking costs may be nearly as high as the total cost of purchasing automobiles.

Transportation "needs" are dictated by neighborhood and city design, and by the physical relationships between residential areas, areas of employment, schools, and shopping areas—as well as by the details of transportation hardware. A well-designed community may provide access to a multitude of goods and services with few or no vehicle trips. Yet it is obvious that the great appeal of the American system of transportation is that it allows an individual mobility even if she lives in such a community. Attempts to develop self-contained, planned communities lacking this type of freedom and mobility are not likely to do well in American markets. Retirement communities are an exception created by necessity. One of the challenges of transportation technology should be to find a way to maintain the greatest possible freedom of mobility for the elderly and other disadvantaged groups.

Table 3-14.—Personal Transportation, 1969-83

Categories	1969	1977	1983
Licensed drivers/person	0.52	0.60	0.64
Licensed drivers/employed adults:			
Females	0.741	0.875	0.911
Males	0.935	0.954	0.958
Licensed drivers/unemployed adults:			
Females	0.549	0.629	0.642
Males	0.648	0.736	0.760
Miles driven per driver (thousands of miles/year)			
Females	5.41	5.94	6.38
Males	11.35	13.40	13.96
Vehicles/licensed driver	0.70	0.94	0.98
Vehicles/person	0.37	0.56	0.63
Person-trips/person	740.00	990.00	980.00
Person-miles/person (000s)	7.12	8.82	8.48
Miles/trip	9.67	8.87	8.68

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *1983-1984 Personal Transportation Study Nationwide*, Volume I, August 1986, p. 1.1.

The Nation's personal transportation system is mature and surprisingly stable. In spite of radical swings in the price of gasoline, the real cost of operating an automobile has not changed significantly in a generation. At the same time, increased vehicle ownership has meant that auto travel has captured a growing fraction of personal income. The system obviously serves the country well.

There have, of course, been many improvements. Compared with the system that operated in the 1950s, the existing automobile fleet is more differentiated, more reliable, more efficient, and safer. While emissions per vehicle have been reduced by law, the rapid growth in driving has made it difficult for many regions to meet goals established for air quality. Sharp increases in the percentage of adults licensed to drive, and in the number of vehicles per driver (the ratio is now 98 vehicles per 100 drivers) have allowed Americans enormous freedom in personal movement—used to adapt to changing job and housing locations. The "personalization" of transport services has increased to a point where two-thirds of all trips (and 86 percent of all commuting trips) are made alone.

Many of the externalities associated with conventional automobile transportation remain unresolved. A system so completely dominated by automobile travel can leave the elderly, the handicapped, and other groups without acceptable transportation alternatives. More than 13 percent of all U.S. households still own no personal vehicle, greatly limiting their access to an economy dependent on automobile transport.

Heavy dependence on petroleum could place the entire economy at risk in the mid-1990s and beyond. In spite of the fact that the energy efficiency of transport has increased sharply since the early 1970s, other parts of the economy have either done a better job of improving efficiency or have managed to shift to other energy sources. Transport consumed about half of all petroleum used in the United States in 1960. In 1986, transportation used 63 percent of all U.S. petroleum consumed—more oil than the United States produced in that year. Automobiles and light trucks alone are responsible for 40 percent of U.S. petroleum consumption.[122]

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[121] U.S. Energy Information Administration, Residential Transportation Energy Consumption Survey, "Consumption Patterns of Household Vehicles, 1983."

Without some fundamental change in automobile petroleum use, demand can be met only by increasing imports to levels higher than they were during the peak period of the 1970s, at a time when Middle East producers will have a much higher fraction of all producing capacity than they did when OPEC (Organization of Petroleum Exporting Countries) was formed. Progress will need to begin soon if any reform is to have an effect in 15 years.

Apart from dangerous dependence on foreign oil imports, transportation presents the economy with a series of problems that have proven difficult to resolve. In most areas, automobiles and other vehicles are responsible for the bulk of air quality problems. At least 30 major cities are not likely to meet 1988 air quality goals established in a 1977 congressional amendment to the Clean Air Act.

Fatalities and injuries resulting from automobile and other forms of transport have fallen, but not as rapidly as other forms of accidental death. Motor vehicle accidents accounted for more than 45,000 fatalities in 1985, and are the third largest cause of death in the United States and the leading cause of death for young males. The greater differentiation of vehicles on the road may have contributed to the problem of safety. Rule changes permit increasingly large trucks on public highways at the same time that automobiles are decreasing in size.

Trends in Personal Transport

The average American (man, woman, and child) now travels about 13,500 miles a year (see table 3-15). The average adult male spends 90 minutes a day traveling and women spend more than an hour a day (see table 3-16). The amount of travel depends on the region and the type of household. Distances and time in travel are increasing slowly.[123] Measured as a percentage of non-defense purchases, public and private spending for transportation has remained surprisingly constant for more than a generation. The mix of spending for transportation services has, however, changed slowly over time (see table 3-17). A slow increase in spending for personal transport has offset a decline in government spending resulting primarily from the steady drop in new State and local highway construction.

Table 3-15.—U.S. Per Capita Passenger Travel in 1984

Mode/vehicle type	Miles per person	
All modes	**13,586**	
Personal transport	10,815	
Automobiles		8,884
Motorcycles		58
Personal light trucks		1,873
Buses	517	
Transit		79
Intercity		113
School		325
Air	1,065	
Certified route air carrier		1,013
Other		52
Rail	61	
Intercity		18
Transit		43

SOURCE: Calculated from U.S. Department of Energy, Office of Transportation Systems, *Transportation Energy Data Book*, Oak Ridge National Laboratory, ORNL-6325, edition, April 1987, table 1.16.

Table 3-16.—Minutes Per Day Spent in Travel

	Men		Women	
	1975	1985	1975	1985
Work Travel	25	31	9	17
Family Travel	33	31	33	33
Leisure Travel	27	33	21	23
Total	85	94	63	73

SOURCE: John P. Robinson, "Trends in Americans' Use of Time: Some Preliminary 1975-1985 Comparisons," Survey Research Center, University of Maryland, December 1986.

But do these changes indicate progress or the lack there of? While transport can be an end in itself, it is mostly a means to an end. Does increasing per capita spending for transportation mean that additional or qualitatively new services are being provided and that Americans are enjoying more mobility, or does it mean that more time and money are being spent to procure the same set of transportation services?

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[122] P.D. Patterson, "Analysis of Future Transportation Petroleum Demand and Efficiency Improvements," paper delivered at the IEA Energy Demand Analysis Symposium, Paris, Oct. 12-14, 1987.

[123] L.D. Burns, *Transportation, Temporal, and Spatial Components o*ı *Accessibility* (Lexington, MA: Lexington Books, 1979).

Changing demographics, such as the decline in family size, the growth of multiple-worker families, the suburbanization of job location, and changing lifestyles all translate into different transportation needs. Shrinking household sizes and an increase in the percentage of women in the work force (women tend to work closer to their homes than men) has actually led to a decline in miles of commuting per household (see table 3-18).

The harried life of many families is reflected in changed use of personal transportation. Table 3-18 shows a sharp increase in family travel for shopping and other purposes and a decline in recreational travel distances.

Continued suburban development also shapes travel needs. Even in 1970, less than 4 percent of all commuting went from suburban areas to the central business district.[124] By 1980, 60 percent of the 31 million commuters in the Nation's 25 largest urban areas lived in suburban areas and traveled to jobs outside the central business district. About half of all commutes in other metropolitan areas involved such trips. There are, of course, significant regional differences. While older cities such as San Francisco and Minneapolis still have vigorous downtown areas, many cities that have expanded rapidly in the past decade have several centers rather than one.

Table 3-17.—U.S. Consumption of Transportation (in billions of current dollars)

Type of purchase	1955	1965	1985
Personal transport	**35.8**	**62.8**	**357.7**
Household spending	31.9	55.3	329.8
New autos	13.8	21.4	86.9
Used autos	1.9	3.8	34.5
Other motor vehicles	0.5	1.3	31.3
Tires, accessories	1.6	3.5	25.0
Repair, washing	3.9	7.6	48.3
Gas and oil	8.6	14.8	92.6
Bridge, tunnel fees	0.2	0.5	1.3
Insurance	1.4	2.4	9.9
Public spending	3.9	7.5	27.9
Highways[a]	3.9	7.5	27.9
Urban public transport	**1.9**	**2.1**	**8.7**
Household spending	1.9	2.0	7.1
Transit	1.3	1.3	3.5
Taxicab	0.5	0.6	3.1
Commuter rail	0.1	0.1	0.5
Public spending	0.0	0.1	1.6
Transit	0.0	0.1	1.6
Other transport	**1.1**	**2.5**	**26.2**
Household spending	1.0	2.0	20.1
Other rail	0.4	0.3	0.6
Bus	0.3	0.4	1.2
Airline	0.3	1.3	18.3
Travel agents, airport, bus, etc.	0.0	0.1	1.9
Public spending	0.1	0.5	6.1
Water & air[a]	0.1	0.5	5.9
Rail[a]	0.0	0.0	0.2
Total transportation	**38.9**	**67.4**	**392.6**
Household	**34.8**	**59.3**	**357.0**
Public	**4.1**	**8.1**	**35.6**
Percentage distribution of spending:			
Personal transport	**92.0%**	**93.2%**	**91.1%**
Household	82.0	82.0	84.0
Public	10.0	11.1	7.1
Urban public transport	**4.9**	**3.1**	**2.2**
Household	4.9	3.0	1.8
Public	0.0	0.1	0.4
Other transport	**2.8**	**3.7**	**6.7**
Household	2.6	3.0	5.1
Public	0.2	0.7	1.6
Total	100.0	100.0	100.0

[a] Spending in these categories has been allocated between final demand (shown here) and spending by government that supports intermediate use of transportation. The support of intermediate transportation is counted in the "government not elsewhere classified" amenity category. Spending is partitioned by the ratio between final commodity demand and total commodity output shown for air, water, and rail in the 1977 input/output tables (U.S. Department of Commerce, Bureau of Economic Analysis). Highway spending attributed to final demand was calculated by taking total highway spending and multiplying by the ratio between user fees collected from private automobiles to all highway user fees.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, historical diskettes, tables 2.4, 3.15 and 3.16.

Table 3-18.—Vehicle Miles of Travel Per Household in Personal Vehicles

	Miles traveled in 1983 (thousands)	Percent of 1983 total	Percent change 1969-1983
Work	4.03	34.4	−22.0
To or from work	3.54	30.1	−15.4
Work related business	0.50	4.2	−49.8
Family and personal	3.56	30.3	47.9
Shopping	1.57	13.3	68.7
Other	1.99	16.9	34.9
Civic, educational, and religious	0.48	4.1	−20.9
Social and recreational	3.53	30.1	−13.7
Vacation	0.25	2.1	−22.1
Visit friends/relatives	1.59	13.5	6.1
Pleasure driving	0.13	1.1	−65.4
Other	1.56	13.3	−17.4
Other	0.14	1.2	−8.7
Total	11.74	100.0	−5.5

SOURCE: U.S. Department of Transportation, Federal Highway Administration, *1983-1984 Nationwide Personal Transportation Study*, vol. I, Washington, DC, August 1986, table 5-2.

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[124] Urban Mass Transportation Administration Technical Assistance Program, Joint Center for Policy Studies, *Demographic Change and Recent Worktrip Travel Trends* (UMTA-DC-09-7009), Washington, DC, February 1985.

Table 3-19 shows how different commuting needs translate into commuting times. The time people are willing to invest in commuting seems to have changed relatively little in a hundred years. Commuters appear to put a comparatively low value on commuting time for the first 20 minutes and approach psychological limits after 45 minutes. The availability of car telephones, sound equipment, and other amenities in vehicles does not appear to have changed the basic formula. In 1980, only 10 percent of all workers commuted more than 44 minutes.[125] Ironically, higher income workers have slightly greater average commuting times and travel longer distances to work.

On average, commuting distances have increased somewhat, while commuting times have decreased. Severe congestion problems plague many major cities. Commuting times increased in metropolitan areas with populations over 3 million between 1969 and 1983. Congestion was identified as a major problem by residents polled in San Francisco, Atlanta, Phoenix, Washington, DC, and a dozen other urbanized areas.[126] Undoubtedly, some of the difficulty results from the growing reluctance of Federal or State governments to pay for highway improvements.

Table 3-19.—Commuting Times by Home and Job Location in 1980

Type of trip	Average travel time (minutes)
Living in a central city and commuting to:	
CBD[a] of central city	24.9
Central city outside the CBD	20.0
Outside central city	26.4
Living in the urban fringe and commuting to:	
CBD of central city	35.1
Central city outside the CBD	27.2
Outside central city	18.8

[a] CBD = Central Business District.

SOURCE: U.S. Department of Transportation, Urban Mass Transportation Administration, *Demographic Change and Recent Worktrip Travel Trends* (UMTA-DC-09-7009), Washington, DC, February, 1985, p. 36.

New freeway construction has all but disappeared. User fees no longer cover highway construction and maintenance costs.[127] Between 1930 and 1950, the length of paved highways per person in the United States climbed from 30 feet to 70 feet, but highway length has scarcely matched population growth since the 1960s.[128] Between 1970 and 1985, the number of automobiles in the United States increased 54 percent but the number of miles of roads and highways increased only 4 percent.[129]

Not surprisingly, the longest commutes were made by those living in an urban fringe and working in a central business district (35.1 minutes in 1980) while the shortest trips involved the growing number of individuals living in the urban fringe and commuting outside a central city (see again see table 3-19). The longer trips associated with shopping and other personal business (again see figure 3-18) are undoubtedly also traceable to the longer trips required for such purposes in suburban areas. Denver, for example, has six shopping centers that have more retail sales than the downtown area.

Commuting patterns are also becoming complex as women enter the work force. Many of the differences between male and female driving habits are beginning to disappear. Women, particularly younger women, are getting driver's licenses in nearly the same percentages as men (again see table 3-14) and are driving greater distances. Working women make "chained" trips, involving a trip to a child care center and perhaps a shopping area before and after work.[130] Women who both work and live in suburbs have a 75 percent higher probability of handling shopping and child care than men. In spite of the increased travel for working women, women still drive half as many miles as men.

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[125] U.S. Departments of Commerce and of Housing and Urban Development, *Annual Housing Survey: 1980, Part F—Energy Related Housing Characteristics* (Washington, DC: U.S. Government Printing Office, 1983), p. 76, in Anthony Downs, "Impacts of Rising Traffic Congestion on the Location of Activities within Metropolitan Areas," April 1985.

[126] R. Cervero, op. cit., footnote 99; Robert Dunphy, "Urban Traffic Congestion: A National Crisis?" *Urban Land*, vol. 44, No. 10, 1985, pp. 2-7.

[127] "Automobile Facts and Figures," in U.S. Congress, Office of Technology Assessment, "Transportation," sector study, Washington, DC, 1987.

[128] Calculated from data in the U.S. Bureau of the Census, *Historical Statistics of the United States, 1776-1976* and the *Statistical Abstract of the United States 1987*, op. cit., footnote 39.

[129] *Statistical Abstract of the United States 1987*, op. cit., footnote 39.

[130] William M. Michelson, "The Impact of Changing Women's Roles on Transportation Needs and Usage," prepared for the U.S. Department of Transportation, Washington, DC, September 1983; Julio Perez-Cerezo, *Women Commuting to Work in the Suburbs* (Berkeley, CA: University of California, Department of City and Regional Planning, 1985).

With the need for individual transport increasing, the number of cars added in the United States has far exceeded population growth for nearly a generation. There is nearly one personal vehicle for every licensed driver in the United States, and 0.63 personal vehicles for every American. The average American goes on nearly 1,000 trips and travels 8,480 miles in some kind of personal vehicle each year. There does, however, seem to be some saturation. Between 1969 and 1977, trips became somewhat shorter even though both trips per person and miles per person increased. Some of this was attributable to an increase in the number of vehicles available to each family. Since 1977, however, there has not been a significant increase in either trips or miles traveled per person.

The preeminence of the automobile is challenged only by air travel for very long trips; interestingly, however, trips by air have grown largely as a substitute for rail and bus journeys. Nearly 84 percent of all trips longer than 100 miles were still made in cars in 1982—down surprisingly little from a 90 percent share in 1960.

Air travel (including business as well as private passenger travel) has grown steadily, from about 4 percent of all miles traveled in 1960 to nearly 15 percent in 1984.[131] The growth in share of trips has come largely at the expense of trips made by rail, bus, and other forms of public transport. The share of land-based public transport for inter-city and intracity trips has declined steadily in recent decades; in some cases, travel by these modes has declined in absolute terms. Deregulation of air travel has reduced services to many smaller towns and cities, with the effect that some trips by air are now taken by other means or, at a minimum, involve a highway trip to a neighboring airport. The effect is important since many of these relatively small centers have experienced rapid population growth in recent years. Future growth in air travel may depend on techniques to reduce total travel time, including the time needed to reach the airport.

While air travel costs have declined and productivity has increased, the air transport system also appears to be headed for stagnation. The performance of the air transport system cannot be decoupled from that of the highway system, since the efficiency of air travel is reduced significantly by delays and congestion encountered reaching an airport by automobile or other means. Including travel time to an airport, travel time between cities less than 500 miles apart has not changed significantly in a generation. Travel time between New York and Philadelphia, for example, required an hour and fifty minutes by train and an hour and thirty minutes by air in 1986 (including travel time to the airport).

Studies indicate that 6 to 10 major U.S. airports either already face severe bottlenecks due to lack of "curbside" for connecting highway to air travel networks, or will face such problems in the future. This lack of progress is ironic, given the extremely high value that air travellers apparently place on their time. Other reports suggest that a large group of air travellers are willing to pay $30 to $60 per hour of time saved in bus travel to or from an airport.[132]

Looking to the Future

Virtually all attempts to make improvements in the performance of the transportation system have met with failure. Public transportation has lost ground in spite of massive subsidies and a growth of urban workers during the past decade.

New technologies can help in a variety of ways. The near doubling of automobile fuel economy between 1974 and 1984 had a major effect on world oil markets. With fuel economy at 1974 levels, the United States would now be importing approximately $40 billion more oil each year. Innovations in vehicle designs could triple fuel economy by the end of the century.

A variety of other technologies could work to improve real system performance. Methanol, made from natural gas, coal, urban waste, or biological materials, could provide an acceptable substitute for petroleum by the next century if steps to plan for the conversion are taken in the near future.

Significant improvements in the net performance of the system, however, require attention not just to the technology of vehicles but to the entire transportation network. Fuel efficiency improvements can easily be offset by heavy congestion and long commutes. New vehicles may require new kinds of guideways. Real productivity changes in transportation may require zoning permits and other mechanisms influencing the design of communities. Communication technologies could provide better traffic control, and possibly give drivers better guidance about which routes are least congested. Progress in these areas depends on a skillful mix of public and private decisions.

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[131] U.S. Bureau of the Census, *Statistical Abstract of the United States 1986* (106th ed.), Washington, DC, pp. 26 and 591.

[132] Greg W. Harvey, "A Study of Airport Access Mode Choice," *Journal of Transportation Engineering*, vol. 112, No. 5, September 1986, pp. 525-545.

Conventional public transit systems do not appear to offer much hope as an alternative to private vehicles. Even in the best of circumstances, the systems work well only during periods when there is a high demand for movement along a well defined corridor. But with the complex patterns of living and working emerging in today's suburban society, such corridors are increasingly rare. Uncertainty about patterns of economic growth increases the risk of investments in relatively inflexible systems along fixed routes.

The American distaste for the comparative inflexibilities and inconveniences of public transit is obvious. Between 1970 and 1980, real family income declined, the number of workers living in urban areas increased by 15 million, large new public transit investments were made in Washington DC, Atlanta, and San Francisco, and large operating subsidies meant that cost of public transit rose only 44 percent while the cost of owning and operating an auto increased 250 percent (gasoline prices tripled). Nonetheless, public transit ridership fell from 8.9 percent to 6.4 percent of journey to work, while the use of personal vehicles for the journey to work increased from 80.2 to 85.7 percent.

With the exception of systems like BART (the Bay Area Rapid Transit system in and around San Francisco), designed primarily to relieve congestion in areas where incomes are high, mass transit remains the option of last resort, and its use is virtually a measure of the extent to which groups are disadvantaged by the U.S. transportation system. The exceptions are those using the system to commute to a central business district, and people living in areas of the northeast (particularly New York) traditionally served with good transit. The average one-way travel time for workers using public transportation (42.2 minutes in 1980) was more than twice that of workers using automobiles (20.8 minutes). Nationwide, in 1980:

- 36 percent of transit riders lived in households with no auto available;
- blacks were three times as likely as whites to use public transit;
- 31 percent commuted into a central business district;
- 25 percent of workers living in a building with 50 or more housing units used public transport, while only 7.1 percent of workers living in detached single-family dwellings used public transport; and
- minorities, older workers, women, and the working poor were more likely to use public transit than other groups.

People with other options leave the transit system rapidly. Ridership has fallen as even the poor are able to purchase vehicles. The number of households with no vehicles fell from 20.6 to 13.5 percent between 1969 and 1983 (see table 3-20). Teenagers (sometimes considered a group disadvantaged by the auto-based transport system) actually reduced usage of public transport between 1970 and 1980.

Moreover, the labor problems associated with operating a system with morning and evening peaks, separated by very low densities, makes traditional transit systems uneconomical in many areas—particularly those experiencing the most rapid growth. Between 1960 and 1983, private spending on public transport other than air travel actually fell by 1.3 percent per year. Government spending for public transportation projects, however, increased rapidly during the period, even though the use of most public transit systems declined.

In many areas the bulk of these subsidies have benefited middle and upper income groups rather than the poor, though the poor tend to pay a greater

Table 3-20.—Vehicle Ownership by Households

Percent owning:	1969	1983	Percent Change
No vehicle	20.6	13.5	−34.5
One vehicle	48.4	33.7	−30.3
Two vehicles	26.4	33.5	26.9
Three or more vehicles	4.6	19.3	319.5

SOURCE: "Automobile Facts and Figures," U.S. Congress, Office of Technology Assessment, "Tranportation," sector study, Washington, DC, 1987.

fraction of their incomes to subsidize the systems since most systems are paid for through non-progressive taxes.[133] Subsidies for transit systems have been justified by a desire to generate growth at suburban sub-centers. While this has worked in some areas, in others desired growth either has not occurred or has actually been opposed by local residents.[134]

There has, however, been a dramatic if poorly documented increase in alternative forms of public transport. Some are private systems serving specialized markets, such as limousines and vans serving hotels and airports. Others are supported at public expense. The State of California provides coupons to low-income and elderly people that can be used to purchase trips to shopping areas or health centers in their community; taxi companies offer the State volume discounts. It must be recognized, of course, that one of the advantages of para-transit alternatives to conventional public systems is the difference in wage rates. Traditional bus and transit jobs, at least in larger cities, tend to be unionized and pay an average of $11 to $13 per hour ($18,000 to $25,000 per year). Para-transit operators average $4 to $6 per hour ($12,000 to $15,000 per year).[135]

Choices and Consequences

Is it then possible to envision a transport system, based primarily on personal vehicles, that could offer greater flexibility, diversity, and freedom of choice to the American public? The answer appears to be "yes, but . . . ." Changes permitting real improvement in mobility through greater differentiation, cost reduction, or speed will require basic changes in the design of guideways, control systems, and parking strategies. Where feasible, they may require new strategies of community design to minimize travel needs and integrate pedestrian and non-pedestrian travel.

The emergence of such systems will obviously require a mixture of public and private investments. They will also require coordinated planning and a long time to implement. Highway and air travel are particularly dependent on Federal, State, and local investments in infrastructure, signaling and traffic control, and terminals; fundamental change can be undertaken only through a combination of public and private decisions.

The future seems to belong to a personal transportation system capable of providing the personal and flexible service demanded by a rapidly shifting economy. Table 3-21 illustrates the difference between car ownership and car usage patterns. While there has been some differentiation in car size in recent years, a large mismatch between vehicle capacity and vehicle use remains. Less than 3 percent of all cars on the road are designed for two passengers (mostly Corvettes, Fieros, and other sports cars). More than 96 percent of all work trips, 87 percent of car trips of all kinds, and 83 percent of all vehicle miles traveled could have been taken in a two-passenger vehicle in 1983. Six-passenger cars are full on 0.5 percent of all trips. The increased individual mobility resulting from greater vehicle ownership has lead to a steady decline in vehicle oc-

Table 3-21.—Use and Ownership Patterns of Personal Vehicles in the U.S. Fleet, 1983 (in percent)

	Number of trips				Vehicle miles traveled	
	Earning a living		All purposes		All purposes	
Number of occupants	1977	1983	1977	1983	1977	1983
One	31.2%	86.4%	59.6%	65.7%	51.7%	57.4%
Two	94.6	96.2	84.3	87.2	79.4	83.1
Three	98.0	98.8	92.6	94.6	89.1	91.4
Four	99.2	99.5	97.0	98.0	95.3	96.6
Five	99.6	99.7	98.8	99.2	98.1	98.7
Six & up	100.0	100.0	100.0	100.0	100.0	100.0

How to Read the Above: Of all U.S. automobile trips to work made in 1977, 81.2 percent were made with one person in the car, 94.6 percent were made with two people, etc. In the same year, 51.7 percent of all vehicle miles traveled were made with one person in the car.

Size of U.S. automobiles by size (in percent):

Size class	1985 stock	1985 sales	1986 sales
Two-seater	2.1%	3.3%	2.5%
Minicompact	4.8	1.0	1.7
Subcompact	22.7	22.0	22.4
Compact	17.1	32.7	33.2
Midsize	28.4	28.0	26.9
Large	24.8	13.0	13.2

SOURCE: For type of trip, see U.S. Congress, Office of Technology Assessment, "Transportation," sector study, Washington, DC, 1987. For stock and sales, see U.S. Department of Energy, Office of Transportation Systems, *Transportation Energy Data Book*, Oak Ridge National Laboratory (ORNL-6325), edition 9, April 1987, pp. xvii and 2-29.

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[133] M. Weber, "The BART Experience—What Have We Learned," Monograph No. 26, Institute of Urban and Regional Development, University of California, Berkeley, CA, 1976.

[134] Ibid.

[135] "Top Hourly Wage Rate Summaries Update," American Public Transit Association, various years; reports of various State public utilities commissions.

cupancy. On average, more than two people ride in vehicles only for trips longer than 20 miles, when families with two adults and young children travel for religious, social, or recreational purposes, for families with young children, or for family business.[136]

There appears to be a large potential market for vehicles designed to serve the needs of those traveling alone or in pairs. Actual purchasing decisions, of course, are based on the assumption that the vehicle may need to be used occasionally to carry large luggage loads or a large number of people. With many cars available, however, large families use large cars primarily for "surge" capacity. Given alternatives, or faced with problems resulting from fuel costs or congestion, many individuals might elect to purchase vehicles better matched to their dominant transportation needs and simply rent trucks or larger automobiles for the rare occasions when they are needed.

Travel in pick-up trucks is an extreme example of poor capacity utilization, since most are driven as personal vehicles with no loads. Pick-ups accounted for 14 percent of all personal vehicles in 1983 and slightly more than 14 percent of all vehicle miles.[137] Nearly 57 percent of the 33.8 million trucks on the road in 1982 were used principally for personal trips.[138] Measured in vehicle miles traveled, use of light trucks is growing 3.4 times faster than use of automobiles.[139]

Considering the Possibilities

Scenarios for the future presented here are all built on the assumption that autos will continue to dominate personal transportation markets in the United States. The Trend scenarios differ from the Alternative scenarios principally by assuming that in the Alternatives, there will be greater product differentiation and higher fuel efficiencies, and there will be a rationalization of the location of airports and systems for transferring from aircraft to other forms of transport.

Automobile travel today depends exclusively on a large, general purpose vehicle operated on highway lanes up to 12 feet in width and requiring parking spaces sized to the vehicle at all destinations. A future system might seek to tailor vehicles more closely to trip functions. Work trips could be undertaken in a small, high velocity vehicle designed for one person but with room for one other person or some baggage. The vehicle could be inexpensive (as little as $2,000), run at 100 miles per gallon, and be parked in a small space. The vehicle could be designed to have good ride characteristics and handling. General Motors has such a vehicle in an advanced stage of development and several foreign producers are considering alternatives.

While the vehicle could operate on standard highways with special lanes and parking spaces carved out of existing facilities—increasing capacity because of the smaller vehicle size—it would be preferable to develop special roads for these small vehicles. Separate lanes and fly-overs could be much less expensive to construct than standard highways, since the lanes could be half the width of lanes built for conventional traffic and would require significantly less structural strength if they did not need to carry heavy trucks.

Even with the conventional car fleet, fuel efficiency can be improved substantially within acceptable cost ranges if a market for efficiency develops. Table 3-22 indicates the kinds of vehicles in testing. Fuel economies as high as 98 miles per gallon are possible even for comparatively roomy vehicles capable of carrying 4 to 5 passengers.[140]

A "neighborhood car" with associated infrastructure could be developed for trips that did not require high speed travel. An inexpensive vehicle, designed for low-speed operation over relatively short distances, could improve the attractiveness of neighborhoods and could significantly increase the mobility of the elderly, the very young, and households not able to afford a conventional vehicle. Protected operating environments could be fitted into local street networks to permit safe operation. The vehicles could be highly efficient, use a variety of non-petroleum based fuels, and be relatively non-polluting.

An illustration of some alternatives for future car transport is given in table 3-23. This table explores

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[136] "Transportation," op. cit., footnote 127.

[137] Ibid. Pickups traveled an average of 10,550 miles per year, while automobiles average 10,055 miles per year.

[138] U.S. Department of Commerce, Bureau of the Census, *1982 Census of Transportation*, "Truck Inventory and Use Survey."

[139] Patterson, op. cit., footnote 122.

[140] See Debby Blevis, *Preparing for the 1990s: The World Automotive Industry and Prospects for Future Fuel Economy Innovation in Light Vehicles*, Federation of American Scientists, January 1987.

Table 3-22.—Fuel Economy of Test and Prototype Vehicles

	Fuel economy (miles/gallon)	Maximum power (HP)	Curb weight (pounds)	Capacity (persons)
Commercial:				
1986 Honda CRX	54	60	1,700	2
1986 Chevy/Suzuki Sprint	57	48	1,500	4
1985 Ford Escort[d]	55	52	2,100	5
Prototype:				
VW Auto 2,000[d]	66	60	1,700	4-5
Volvo LCP 2,000[m]	69	60/90	1,600	2-4
Renault EVE[d]	70	50	1,900	4-5
Toyota Compact[d]	98	56	1,400	4-5

NOTES: For U.S. vehicles, efficiencies use EPA combined fuel economy. European and Japanese prototype data were converted to EPA test values using conversion factors recommended by the International Energy Agency. Unless otherwise indicated, the vehicles use gasoline as a fuel, (D) indicates a diesel vehicle, (M) indicates a multi-fuel vehicle.

SOURCE: Robert H. Williams, "A Major Role for Developing Countries in Promoting Super Efficient Cars," paper presented at San Palo Workshop, November 1985.

the cost implications of different types of car fleets and car ownership rates, and the implications for gasoline consumption.

Alternatives to conventional public transit can be developed that are more suited to the practicalities of modern commuting, and that provide improved mobility for transportation of the handicapped. It is likely that many of these alternatives would require lower social subsidies than systems built along traditional rail and bus systems. A key to the system would be the use of modern communication systems to dispatch a variety of vehicles to neighborhood stops, homes, or businesses on demand. Customers could choose from a variety of vehicles, ranging from demand-responsive taxis to para-transit services. Some of these options would offer subsidized fares to those needing assistance.

Jet aircraft are not well designed for short flights, and service for long-haul flights is becoming increasingly concentrated at hubs not easily accessible to many towns. Systemic performance could be improved with a better system of hubs, designed to provide service to a wide region through improved land vehicle and high-speed rail links as well as short-haul aircraft. The system's performance can be optimized only by considering all elements of the transportation link.

While these strategies could radically improve the performance of the transportation system, few of them depend on the development of radically new technologies. However, their introduction requires solutions to political and institutional problems that can be much more difficult to resolve than sophisti-

Table 3-23.—Background Assumptions for Transportation Scenarios

A. Use and Distribution of Vehicles

	Two person	Four person	Six person	Cars per adult[a]	Miles per adult
1983	2	38	60	0.65	8.6
2005:					
Baseline[c]	2	38	60	0.65	10.0[b]
Case #1[d]	18	32	50	0.65	8.6[c]
Case #2[e]	44	28	28	0.75[f]	10.0[g]
Case #3[h]	35	25	40	0.85[i]	10.0

B. Cost of Vehicles

	Total vehicle purchases (millions)	Average price/ vehicle ($1,000)	Total spending on new vehicles (1983 = 1)
1983	7.4	9.6	1.00
2005:			
Baseline	11.3[j]	14.6[k]	2.32
Case #1	8.5[l]	8.5[m]	1.02
Case #2	10.8[l]	9.8[m]	1.49
Case #3	17.0[j]	7.4[k]	1.77

C. Fuel Efficiency of Vehicles

	Total vehicle miles (billions)	Average miles per gallon[n]	Spending on gasoline (1983 = 1)
1983	1,465	16.5	1.00
2005:			
Baseline	2,140	26.7	0.90
Case #1	1,840	44	0.47
Case #2	2,140	59	0.40
Case #3	2,140	53	0.45

[a] For these calculations, an adult is a person aged 16 to 75.
[b] Assumes that car miles per adult will increase at the rate prevailing from 1960 to 1984.
[c] Unchanged from 1983.
[d] Mix changed to reflect the "extensive downsizing" case used by Melvyn Cheslow, *The Effect of Changing Household Composition on the Size Mix of New Automobile Sales: 1979-2000*, Evaluation Research Corp., Vienna, VA, May 1980.
[e] Following Cheslow, it is assumed that half of all single-person households and half of all children of driving age living at home use two-passenger cars, while the rest drive four-passenger cars.
[f] Assumes that cars per adult will increase at half the average rate of the period 1960 through 1975.
[g] Assumes that car miles per adult will increase at the rate prevailing from 1960 to 1984.
[h] Same mix assumptions as case #1, but assumes that 30 percent of households will also purchase a two-passenger car.
[i] Assumes that cars per adult will increase at the rate of the 1960s.
[j] Calculated assuming cars per adult shown above, and using mid-range forecast showing 214 adults and a 7 percent annual scrap rate per year.
[k] Assumes that new car prices increase at about 1970-1980 rate (recent price increases have been much higher).
[l] Calculated as in (j) above, only using a 5 percent scrap rate.
[m] Assumes that the real price of four- and six-passenger cars do not change, and that a two-passenger car can be purchased for $3,000.
[n] Assumes that a two-passenger car can be built to achieve 90 mpg, a four-passenger car to achieve 40 mpg, and a six-passenger car to achieve 30 mpg.

SOURCE: Office of Technology Assessment.

cated technical problems. Admittedly, building any of these systems would require fundamental changes in traditional design protocols and standards as well as extensive public investment.

New technologies could make significant contributions to conventional transportation systems, as well as facilitate the emergence of changes in transport strategies such as those outlined above. Information technology could play a critical role by optimizing the routing and dispatch of aircraft, public vehicles, and perhaps even personal vehicles, and by optimizing the performance of the vehicles themselves. Advanced control technologies could contribute to improved intercity automobile transportation, and many of the monotonous tasks of driving could thereby be simplified. The driver could be given information on speed limits, distances to exit ramps, and details about road conditions. Car status systems could warn the driver when there are problems in the car that need attention. Electronic safety systems could include night vision equipment, automatic braking, and collision avoidance systems.

Traffic data systems could provide information on traffic situations such as construction and accidents. Local highway departments could also benefit from such services since they could anticipate traffic patterns and demand. The data could be used to improve traffic signalling, and to suggest alternate routes that would distribute traffic more evenly. More effective integration of vehicles and the roadway would make driving easier and safer, and would also reduce travel times and costs. Technology could also play a key role by improving the energy efficiency of vehicles, increasing the safety of vehicles of all sizes, facilitating the development of low-cost and reliable sources of methanol or other non-petroleum fuels, and reducing emissions.

Constructing Scenarios

Expenditures on the Transportation amenity for several different scenarios are illustrated in table 3-24. In most cases, the Trends are derived using methods described in the previous chapter.

A departure from the projection of existing patterns is made for gasoline expenditures, to take into account the increasing share of the post-1973 higher fuel efficiency automobiles in the total vehicle fleet. For the 3 percent Trend scenario (the 2005 baseline case), it was assumed that miles per gallon rose to 27 compared with 17 in 1983, and that miles driven per adult rose by 16 percent over 1983 levels—roughly a continuation of an historical trend. The same fuel efficiencies are assumed for the 1.5 percent Trend case. Because of the lower growth rate, miles per adult are assumed to remain at the 1983 level.

Table 3-24.—Consumption Scenarios for Transportation (billions of 1983 dollars)

		2005			
	1983	Trend 3%	Trend 1.5%	ALT 3%	ALT 1.5%
Vehicles	109	192[a]	140[a]	192[e]	162[f]
Vehicle maintenance	72	134[a]	98[a]	135[b]	114[b]
Gas and oil	90	81[c]	75[d]	41[e]	36[f]
Air fares	15	42[a]	22[a]	52[g]	23[g]
Other public transport	9	13[a]	10[a]	10[h]	7[h]
Total	295	462	346	430	346
Government purchases[i]	48	91	66	130	94
Total	343	553	412	560	440
Percent share of GNP	10.1	8.5	8.7	8.6	9.3

ABBREVIATIONS: ALT = alternative scenario, GNP = gross national product

[a] Computed using extrapolative techniques described in ch. 2.

[b] Scaled to vehicle purchase amount using the ratios calculated for the Trend case.

[c] Baseline case in table 3-23

[d] Baseline efficiency from table 3-23 with an assumption that miles/adult increases at half the rate shown in the case where economic growth doubled.

[e] Based on case #3 in table 3-23

[f] Based on case #2 in table 3-23

[g] Assumed increase in expenditure due to a 10 percent fall in airline prices, in contrast to stable prices assumed for Trend scenarios.

[h] Expenditure on public transport arbitrarily reduced by 10 percent because of greater private mobility.

[i] Assumed to be 10 percent of total government purchases following trend of past decade.

SOURCE: Office of Technology Assessment, 1987.

The main difference between the Alternative high and low growth scenarios is the extent to which personal vehicles are purchased as a replacement for existing vehicles or in addition to them. These two scenarios are constructed from cases 2 and 3 of table 3-23, respectively. That is, the 3 percent Alternative scenario provides for a higher vehicle ownership, a car fleet with more large cars, and rather lower fuel efficiencies than the 1.5 percent case. Vehicle miles are similar in both cases. A comparison between the Trend and the Alternative scenarios suggests that increased mobility could be achieved in both the 1.5 and 3 percent cases at a minimal increase in vehicle expenditure and a reduction in gasoline costs.

For air fares, it is assumed in the Alternative case that fares decline by 10 percent in real terms instead of staying constant as in the Trend scenarios, and that expenditures on air travel consequently increase. This higher level of expenditure in the 3 percent Alternative case is in line with historical trends. The relatively small expenditure on "other public transport" is assumed to be 10 percent lower in the Alternative case, in recognition of the greater private mobility that this scenario envisages. Government purchases of transport—roads, waterways, etc.—are assumed to rise in all cases due to the need to provide infrastructure for increased mobility. The increase in the Alternative cases is sharper, as special guideways for the new vehicles would be needed.

Total expenditures on Transportation under the 3 percent Alternative would therefore be about the same as in the 3 percent Trend scenario, but the Alternative allows for increased mobility. Greater mobility is also incorporated in the 1.5 percent Alternative case, but here expenditure would be some 7 percent higher than in the 1.5 percent Trend scenario. The income distribution scenarios suggest that people place a high priority on increased mobility as incomes rise.

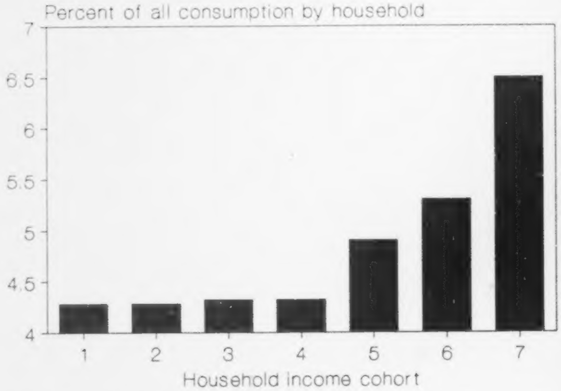
CLOTHING AND PERSONAL CARE

The category "Clothing and Personal Care" includes clothing and shoes, jewelry and toiletries, and the services associated with these commodities. This section focuses primarily on apparel, which represents roughly three-quarters of consumer expenditures in this area.

Both men and women demonstrate strong interest in the communicative quality of their clothing, and its ability to influence image, career advancement, and self-esteem. Personal spending on high-priced fashion products—which generally remain popular for only ten weeks before being replaced by another style—is increasing rapidly.[141]

Apparel retailers face the challenging opportunity of the coming of age of those born during the baby boom. With the oldest of this group now approaching 40 and the youngest just leaving college, this generation is entering its prime years of earning and spending, and it will have an enormous influence on apparel markets for the next 20 to 40 years.[142] Households headed by individuals between the ages of 35 and 54 have, on average, the highest household income, and spend more on apparel (and textiles) as a percentage of total expenditures than other households. As figure 3-7 demonstrates, the portion of household spending that goes to apparel increases with rising household income.[143]

Figure 3-7.-Apparel Consumption



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, "Consumer Expenditure Survey, 1982/83," unpublished data, 1986.

In constructing the different scenarios, two developments were taken into account. The first is price. Past prices fell in real terms, largely due to competition from low-cost producers abroad. Thus, import penetration ratios[144] rose from 8 to 14 percent between 1974 and 1982. If this trend continues, prices can be expected to remain low. If, on the other hand, additional protection measures are introduced, a powerful stimulus to low prices will be removed.

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[141] U.S. Congress, Office of Technology Assessment, *The U.S. Textile and Apparel Industry: A Revolution in Progress—Special Report*, OTA-TET-332 (Washington, DC: U.S. Government Printing Office, April 1987), p. 16.

[142] U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 986, *Projections of the Number of Households and Families: 1986 to 2000* (Washington, DC: U.S. Government Printing Office, 1986), Table 2, Series B.

[143] OTA, collected from "Consumer Expenditure Survey, 1982/83," U.S. Department of Labor, Bureau of Labor Statistics, unpublished data, 1986.

[144] The ratio of imports to new supply (domestic product shipments plus imports); *Statistical Abstract of the United States 1987*, op. cit., footnote 39, Table 1350.

The second development is technology, which could a have significant impact on clothing in two ways (see ch. 6 for more on this subject):

1. Information technologies in the clothing distribution chain could lower costs by reducing inventories and paperwork, improving productivity of the retail end and cutting the time from order to delivery. This is particularly relevant for domestic producers, whose comparative advantage lies in rapid responsiveness to market changes.
2. Production technologies—including computer-controlled apparel assembly, computer-assisted design and manufacturing techniques, and automated transfer of fabrics—could improve quality, provide a wider range of choice in fabrics and sizes at no extra cost, and enhance flexibility in response to consumer demand. It may soon be possible to use computer-generated images of customers wearing a wide variety of styles and fabrics and have the article made to exact individual measurements (in effect a return to individual tailoring) without a significant increase in cost or production time.

Table 3-25.—Consumption Scenarios for Clothing and Personal Care (billions of 1983 dollars)

		2005			
	1983	Trend 3%	Trend 1.5%	ALT 3%	ALT 1.5%
Clothing	167.4	378.9	238.7	446.0	281.0
Personal care commodities and services	34.4	72.2	51.5	72.0	52.0
Total	201.8	451.1	290.2	518.0	333.0
Percent share of GNP	5.9	6.9	6.2	8.0	7.1

ABBREVIATIONS: ALT = Alternative scenario, GNP = gross national product.
NOTES: Trend scenarios use extrapolative techniques described in ch. 2. In the alternative scenarios, personal care goods and services are as in the Trend scenarios; for clothing, an increase in expenditure is assumed due to declining prices of about 15 percent.
SOURCE: Office of Technology Assessment, 1987.

For these reasons, there is considerable uncertainty about future trends in prices. Scenarios are described in table 3-25. In the Trend scenarios, spending was assumed to follow extrapolative techniques discussed in the previous chapter. In the Alternative scenarios, it is assumed that prices fall by about 15 percent, which is still less than in the past. As a result, expenditures on clothing rise substantially above the trend levels. Total Clothing and Personal Care expenditures in the Alternatives would reach 7 and 8 percent of GNP, compared with 6 and 7 percent in the Trend scenarios.

EDUCATION

Defining Demand for Education

If there is anything certain about the future of the U.S. economy, it is that the demands on the Nation's educational system will increase. While it is flatly impossible to predict precisely which skills will be needed in a successful future economy, all evidence suggests that a nation whose wealth depends increasingly on the ability to develop and exploit technical innovations, and on its ability to respond quickly to changing market conditions, will need a workforce that is itself adaptable and flexible. This flexibility requires workers capable of identifying what it is that they need to know in confusing circumstances, and quickly teaching themselves what needs to be learned. Continuous learning is already a major part of the job description of many Americans, and the demand for learning can only increase. Ironically, increased use of information technology is also likely to increase rather than decrease the need for people that can work as a member of a team assembled from individuals with diverse backgrounds and skills.

A system of education designed to provide the economy with the skills needed to prosper in the emerging world economy can be perfectly consistent with a broader set of objectives for the Nation's educational system: the development of a system that could allow all citizens to discover and enjoy the potential of their own intelligence, to have practical access to all knowledge, and to understand and celebrate the accomplishments of the human mind and spirit. This means much more than being able to design a better robot. It means being able to learn about how things work. It means being able to have fun with the wit, the music, the images, or the ideas of people they will never meet. It means having an opportunity to understand the struggles and the compromises that produce free governments. It means increasing each person's freedom and capacity to grow and change. It means increasing each person's capacity for enjoying leisure and retirement.

The correlation between education and an ability to prosper in modern American society go far beyond an ability to get a good job. The strong correlation between education and measures taken to promote good health was noted earlier. Education is strongly correlated with an ability to avoid personal disasters (such as divorce, major unemployment, disability, eviction, or a sharp decline in family income) and an ability to recover from disasters once they occur. The effect is measurable even when adjustments are made to account for the effects of income, IQ, age, region, and race.[145]

America has, of course, always understood the links between education and national wealth and security. Concern about the quality of public education has always been a key part of the long-standing consensus about equal opportunity. Education translates an individual's theoretical right to political and economic freedom into practical powers. Changes in the structure of the national economy are likely to increase the burden on the Nation's educational system for all of these purposes. The burst of industrial expansion following the Civil War was paralleled by unprecedented national legislation establishing the Land Grant College system and setting aside "school sections" for homesteaders. In the 1950s, the Nation responded to the growing technological prowess of the Soviet Union with a massive National Defense Education program. The challenge faced today may be no less critical. The terms of international trade hinge increasingly on an ability to generate and capitalize on ideas, and on a work force trained well enough to adapt quickly to new requirements.

A fundamental difficulty in measuring progress—or the lack of progress—in education is the extraordinary difficulty of measuring the output in any useful way. The complex list of objectives stated above defy precise measurement. If anything, the problem is compounded as the kinds of skills required by the workforce become more abstract. A "skill" today means an ability to translate complex problems into solvable ones, an ability to find out what needs to be learned and to learn it, and an ability to absorb complex and often inconsistent information quickly. These skills are much more difficult to measure than basic bookkeeping, arithmetic, or memory skills. The perpetual problem of management in education is that the system tends to reward results that can be measured (and therefore make progress in what can be measured) while the most important products may go unmeasured. Developing adequate measurement techniques therefore becomes a critical priority for making progress in an educational system.

Developing a consensus on priorities is a difficult process and will require care and leadership. At present, there appears to be a significant gap between the expectations of the teaching profession and that of their clients. Schools are expected to cure social problems ranging from drug abuse to the shortage of babysitters—roles that professional educators do not always find comfortable. Statistics reveal a sharp increase in student interest in practical, job-related skills, and a declining interest in training not directly related to employment objectives. Job-related bachelor's degrees increased from 50 percent of all degrees granted in 1970/71 to 64 percent of degrees granted in 1982/83, while there were sharp declines in degrees granted in the humanities and basic physical and biological sciences.[146] Only 6 percent of the elementary and secondary teachers polled in 1984 thought that helping "students get good/high-paying jobs" deserved the highest rating when given a list of objectives for education, while 46 percent of parents surveyed gave it the highest rating.[147]

Trends in Inputs and Outputs

In 1985, the United States spent between 8 percent of its GNP on education (13 percent if corporate training costs are included). One American in three engaged in some kind of training or educational experience during the year (see table 3-26). Education is not considered to be a form of investment or savings, yet it plainly serves a role as important as investment in plant and equipment. Table 3-26 also shows that spending for education may represent 40 to 80 percent of gross national investment in new plant and equipment, and perhaps twice an large an investment after depreciation (it is difficult to know how to depreciate an investment in education).

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[145] G.J. Duncan, *Years of Poverty Years of Plenty* (Ann Arbor, MI: Institute for Social Research, The University of Michigan, 1984), p. 26.

[146] U.S. Department of Education, Center for Education Statistics, *Digest of Education Statistics 1987* (Washington, DC: U.S. Government Printing Office, May 1987).

[147] Phi Delta Kappan, "The Gallup Poll of Teachers' Attitudes Toward the Public Schools" cited in U.S. Department of Education, *The Condition of Education* (Washington, DC: U.S. Government Printing Office, 1986).

Spending patterns in education have shifted rapidly during the past few decades. A large increase in public spending for education during the 1960s and early 1970s was reversed in the mid 1970s as the baby boom generation left public schools. While statistics are poor, it appears that expenditure on other forms of education increased rapidly.[148] Approximately 23 million people over the age of 17, or 13.5 percent of all adults, took some kind of part-time adult education in 1983—nearly double the rate reported in 1957. Sixty percent of the courses were related to employment. Most adult students were relatively affluent, white-collar workers who had already received a good education. Adult education is paid for by individuals, the Federal Government, and private industry; government and industry expenditures could rise significantly, since more Americans will need to be retrained as new technologies enter the marketplace.

Despite these large expenditures, the record of the U.S. educational system is mixed. While it is undoubtedly possible to obtain a better education in the United States than virtually any other place in the world, the United States appears to let a larger fraction of its population fall through cracks in the system than many of its key trading partners. There are three different ways of measuring progress.

The first involves examining changes in achievement over time. The past 20 years have witnessed a steady increase in time spent in school. Thus the fraction of the school age population that received a high school degree grew steadily during the 1970s, and the number of people seeking higher education also grew quite rapidly.[149] With the decline in available financial support, the correlation between income and education is likely to grow. The percentage of young blacks enrolling in institutions of higher education actually fell between 1984 and 1985.[150]

It is much more difficult to measure the *quality* of the education provided by the American system. Scores in the Scholastic Aptitude Test, designed to predict performance in college, suggest a decline in the educational achievement of high school graduates. Verbal scores fell steadily from 478 in 1963 to a low of 424 in 1981, but rose to 431 in 1985. Mathematical scores fell from 502 in 1963 to 466 in 1981, and are now at 475.[151] Part of the decline and subsequent increase in test scores may be due to changes in the number and type of students taking the tests.

Attempts to measure the quality of "literacy" among U.S. graduates has constantly been frustrated by an inability to define the term with any precision. The number of illiterate Americans is estimated to be between 20 and 60 million. This number increases by 1 to 2 million per year.[152] The growth results primarily from people dropping out of school (15 percent of Americans aged 20 to 24 had not completed high school in 1985), and from large numbers of immigrants. A recent survey of 3,600 young American adults aged 21 to 25 showed a striking range of practical competence (see table 3-27). Approximately 80 percent of all whites and 40 percent of all blacks were able to do simple sums if the problem was presented in a form familiar from school arithmetic tests. Only about 30 of the whites and 2 percent of the blacks taking the test, however, succeeded in solving problems that required taking a simple percentage. Very few people were able to translate a practical problem into quantitative terms.

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[148] See, for example, ch. 6 of U.S. Congress, Office of Technology Assessment, *Information Technology and Its Impact on American Education*, OTA-CIT-187 (Washington, DC: U.S. Government Printing Office, November 1982).

[149] In 1980, only 17 percent of Americans 65-70 years of age had completed a year of college, compared with nearly 45 percent of the 25-29 year olds. The increased numbers participating in higher education in recent years is, however, the result of a rapid growth in the numbers of people entering two-year (rather than four-year) courses of study, with the aim of upgrading job skills rather than receiving a broad liberal education.

[150] *Digest of Education Statistics*, op. cit., footnote 146.

[151] College Entrance Examination Board, "National Report: College Bound Seniors," various years, reported in U.S. Department of Education, Center for Education Statistics, *The Condition of Education* (Washington, DC: U.S. Government Printing Office, 1986).

[152] The lower estimate is based on a 1982 U.S. Department of Census survey of the ability of Americans to understand information describing social services. The higher estimate was produced by Jonathan Kozol in his book *Illiterate America*. The material is cited in R. Deigh, "Curse it, Count it, Cure it. The Arithmetic of Illiteracy," *Insight*, Sept. 29, 1986, pp. 10-14.

Another sign of defects in literacy can be found in the growing need for remedial programs conducted both by employers and by universities. In 1983 to 1984, remedial math courses were taken by 25 percent of all students entering colleges and universities, remedial writing by 21 percent, and reme-

Table 3-26.—The U.S. Education System in 1985

	Spending (billions)	Enrollment (millions)
Primary & secondary[a]	157	46.6[b]
Household	14	
Government	143	
Higher education[a]	65	12.3[b]
Household	16	
Government	49	
Other[a]	41	23.0[c]
Personal spending on education & research	14	
Public libraries & other	9	
Labor training & services	5	
Department of Defense[d]	18[e]	2.0[e]
Business & government training[f]	30-210	
Formal government training	5[g]	
Formal corporate training	25[g]	
Informal training	50-180[h]	
Total	293-472	81.9
Household	43	
Government	232-254	
Corporate	66-175	
For comparison:		
Gross national product	$4,010	
Gross private domestic investment	642	
Net private domestic investment	205	
U.S. population		239

[a] U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, July 1987.

[b] U.S. Department of Education, Center for Education Statistics, *Digest of Education Statistics 1987* (Washington, DC: U.S. Government Printing Office, May 1987).

[c] Enrollment statistics for primary, secondary, and higher education from adult training participation from Office of Educational Research and Improvement, U.S. Census Bureau, cited in U.S. Congress, Office of Technology Assessment, *Technology and Structural Unemployment—Reemploying Displaced Adults*, OTA-ITE-250 (Washington, DC: U.S. Government Printing Office, February 1986). See also *Training Magazine*, October 1984. The figure includes corporate training. There are probably 8 million students in formal learning programs in corporations; see N.P. Eurich, *Corporate Classrooms* (New York, NY: The Carnegie Foundation for the Advancement of Teaching, 1985).

[d] Counted as defense spending in the amenity accounts used in this analysis.

[e] The statistic shown here, based on Orlansky (see below), is higher than the $14 billion shown in the National Income and Product Accounts presumably because Orlansky was able to include training costs otherwise hidden in other DoD accounts. Orlansky's data for 1985 show 469,000 recruits in initial training ($1.7 billion), 1.4 million students obtaining specialized skills including flight training ($6.7 billion, of which flight training is $2.3 billion), and 69,000 associated with officer acquisition and professional development ($1.3 billion); support and other costs account for most of the remaining costs. J. Orlansky, "The Cost Effectiveness of Military Training," *Proceedings of the Symposium on the Military Value and Cost-Effectiveness of Training* (DS/A/DR(85)167), Brussels, Belgium, NATO headquarters, Defense Research Group on the Defense Applications of Research, January 1985, p. 4.

[f] Education and training costs in these categories include training of government and private employees undertaken at the employer's expense. They include formal classroom instruction and informal training that is often difficult to disentangle from routine work—i.e., learning a new word-processing software, or learning a new bureaucratic protocol. They are not considered as a part of "final demand" because they are treated as a part of government spending in other areas, or because they are purchased by private businesses and therefore considered to be "intermediate input." Data in this large and important part of education and training are very poor.

[g] R.L. Craig and C. Evers, "Employers as Educators: The Shadow Education System," G. Gold, ed., *Business and Higher Education: Toward New Alliances* (San Francisco, CA: Jossey-Bass, 1981). The $30 billion estimate for formal training is approximately the same as that derived by applying a cost model to the Survey of Participation in Adult Education or SPAE (U.S. Census), adjusting the results for underreporting that can be estimated when the SPAE participation rates for enrollment are compared with known enrollement statistics in institutions where enrollment is well known (e.g., universities). See A.P. Carnevale and H. Goldstein, "Employee Training: Its Changing Role and An Analysis of New Data," American Society for Training and Development Press, Washington, DC, 1983, in A.P. Carnevale, testimony before the Subcommittee on Taxation and Debt Management of the U.S. Senate Finance Committee, Washington, DC, Nov. 30, 1987. Eurich (see note C) suggests that formal corporate training costs at least $40 billion. A more recent estimate places the corporate training budget in the range of $50-70 billion (R. Neff, "Videos are Starring in More and More Training," *Business Week*, Sept. 7, 1987, p. 110.

[h] The amount paid for training that does not occur in a formal setting is simply not known. Even definitions are difficult since it is often difficult to distinguish between work and learning. (See Carnevale testimony, cited in above note). In 1985, U.S. employers paid approximately $2.5 trillion for employee compensation. Anecdotal evidence suggests that 2-4% of an average employee's time is devoted to some kind of informal learning. This would yield $50-100 billion in informal training costs. Government and corporate shares of total spending in this category are allocated in proportion to spending to formal training.

Table 3-27.—Percent of Young U.S. Adults Able to Perform Tasks Requiring Different Levels of Literacy

Percent[a]	Prose tasks	Document tasks	Quantitative tasks
90-100	Locate information in a sports article	Enter date on a deposit slip	Total bank deposit entry
50-75	Locate information in a news article	Follow directions to travel from one location to another using a map	Enter and calculate checkbook balance
20-30	State in writing argument made in lengthy news article	[b]	Determine tip given as 10% of bill
5-15	Generate unfamiliar theme from a short poem	Use bus schedule to select appropriate bus for given departures & arrivals	Estimate cost using grocery unit price labels

How To Read This Table: Only 10% of the young adults (aged 21-25) taking the test were able to generate an unfamiliar theme from a short poem. 90% were able to total a bank deposit entry.

[a] See the source for precise percentages.
[b] No document task had a % in this range.

SOURCE: National Assessment of Educational Progress, "Literacy: Profiles of America's Young Adults," Educational Testing Service, Princeton NJ, 1986.

dial reading by 16 percent; 82 percent of all colleges and universities are forced to offer such courses.[153] It is reasonable to ask why such resources could not have been spent teaching the students better in the first place.

Another way of gauging quality in American education is to compare U.S. and foreign systems. The U.S. education system no longer has a clear lead over systems elsewhere in the world. The quality of the K-12 education received in the United States may be lower than that delivered by some of our major trading partners.[154] The United States of course has a much more heterogeneous population than most nations. U.S. primary and secondary students regularly score below average in standardized tests. But even U.S. elementary students in a middle class suburb of Minneapolis scored far lower on standardized tests than comparable classes in Japan and Taiwan.[155] The United States does remain ahead of most nations in the fraction of its population receiving some college education.

Still another way to measure quality is to see how efficiently the traditional educational system provides the skills needed for a growing and changing economy. It is not clear that the priorities of the primary and secondary school system are well tuned to the needs of U.S. businesses. While school officials have often cited vocational skills as the most important factor in youth employability, the business view has been that if the schools provided adequately educated youth, business would provide—indeed, overwhelmingly does provide—technical training. What business decidedly indicated it did not want to do, but is in fact doing, is to educate its employees in ninth and tenth grade skills. Of greater importance, there are a number of reports that suggest that the educational system is not geared to producing the skills that will be needed in the future if the Nation is to become fully competitive in a "new-technology" world.[156] In sum, what is known about the productivity of the traditional education system is not reassuring.

Choices and Consequences

Spending levels for education hinge on a variety of factors:

- the number of people in "school age" population groups,
- the fraction of these people who will be enrolled,
- the fraction of the adult population requiring retraining,

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[153] Digest of Education Statistics, op. cit., footnote 146, p. 48.

[154] *The Condition of Education*, op. cit., footnote 151, 1985 edition; *Digest of Educational Statistics*, op. cit., footnote 146, p. 303.

[155] Harold W. Stevenson, Shin-ying Lee, James W. Stigler, "Mathematics Achievement of Chinese, Japanese, and American Children," *Science*, vol. 231, No. 4739, Feb. 14, 1986, p. 693.

[156] Report of Conference on Potential Funders of Education in Mathematics, Science and Technology, Carnegie Corporation, New York, 1985.

- the fraction of adult training that will be purchased by individuals and government agencies and the fraction that will be purchased by private businesses (and therefore not counted as "final consumption" using standard accounting procedures), and
- the techniques employed in teaching at different levels.

The last question is clearly critical. The discussions presented in chapter 6 suggest that it is possible to use innovations in pedagogy, innovations in instructional technology, and improved management to enhance the rate of learning and to make learning more useful and fun. There are two principle innovations:

1. tailoring instruction to the learning styles, interests, and abilities of individuals rather than attempting to force a comparatively homogeneous system on a diverse population, and
2. freeing teachers of routine work so that they can spend more time with individuals.

It is also possible, of course, that pressures to reduce costs will result in more uniform curricula and reduced student access to instructors. The contrasts are stark.

The demographic model described earlier indicates that in the year 2005, the population aged 5 to 24 will be roughly the same as it is today. Many more Americans will be middle-aged by the year 2005, and these individuals are likely to demand more of the Nations's educational system than middle-aged people today. Table 3-28 provides some basic statistics on the number of people in each age group participating in education (not including those engaged in trade schools or correspondence courses). Rates increased for both the youngest and the oldest age groups during the period from 1965 to 1985. A hypothesis about future participation rates is also shown.

Estimates of the number of people requiring education and training are combined with estimates of teaching methods (measured by "intensity" or spending per student) in table 3-29. The assumptions are shown in the notes to the table. The Trend case assumes that teacher salaries will be increased and that increased training will be provided for older age groups. It also assumes that teaching methods remain comparatively unchanged. The Alternative cases, on the other hand, are built around an assumption that teaching strategies are changed in fundamental ways. In K-12 teaching, instruction is divided into three kinds of activities:

1. working with computers and other new technology in a way that requires a minimum amount of direct teacher supervision,
2. participating in tutorial sessions where a single teacher works full time with a small number of students, and
3. standard lectures in which students would listen to an instructor talk and lead group discussions.

Table 3-28.—Factors Affecting Enrollment in Schools

	Population (in millions) by age cohort						
Year	0-4	5-17	18-21	22-24	25-29	30-34	35-44
1983	18.3	45.4	16.7	13.6	21.7	19.6	30.1
1985	18.6	45.4	15.9	13.0	22.5	20.6	32.9
2005	18.7	49.9	16.2	12.2	19.1	19.4	43.9
Percent change (1983-2005)	2.2	9.9	−3.1	−10.3	−11.9	−1.0	45.8

	Participation rates by age cohort								
Year	3&4	5-6	7-13	14-17	18-19	20-21	22-24	25-29	30-44
1965	0.106	0.849	0.994	0.932	0.463	0.276	0.132	0.061	
1985	0.389	0.961	0.992	0.949	0.516	0.353	0.169	0.092	0.025
2005	0.389	0.961	0.992	0.949	0.543	0.391	0.188	0.130	0.100

SOURCE: Participation rates for 1965 and 1985 from U.S. Department of Education, Center for Education Statistics, *Digest of Education Statistics 1987* (Washington, DC: U.S. Government Printing Office, May 1987), p. 12; population computed from demographic model described in ch. 2 using Social Security Administration midrange assumptions—for ages 3-17 participation rates are assumed to be the same in the year 2005 as they were in 1985, for ages 17-24 participation rates grow at approximately half historic rates (with some adjustments), and assumptions for older age groups are speculations based on a rapid growth in demand for retraining.

Table 3-29.—Consumption Scenarios for Education
(billions of 1983 dollars, except where noted)

		2005			
	1983	Trend 3%	Trend 1.5%	ALT 3%	ALT 1.5%
Primary & secondary	134	164[a]	155[a]	206[f]	206[f]
Private	12	14[b]	14[b]	18[b]	18[b]
Government	123	150[b]	142[b]	188[b]	188[b]
$/student	2,983	3,311	3,132	4,150	4,150
Higher education	56	59[c]	59[c]	68[g]	59[g]
Private	13	14[b]	14[b]	16[b]	14[b]
Government	42	45[b]	45[b]	52[b]	45[b]
$/student	4,461	5,131	4,684	5,131	4,461
Other	23	42	32	52	37
Private education & research	11	14[d]	15[c]	14[d]	15[c]
Public libraries & other	8	15[c]	11[c]	15[c]	11[c]
Labor training & services	4	13[e]	6[c]	23[h]	11[h]
Total	**213**	**265**	**246**	**326**	**302**
Private	36	43	43	49	47
Government	177	222	203	277	255
Percent share of gross national product	**6.2**	**4.1**	**5.2**	**5.0**	**7.1**

ABBREVIATIONS: ALT = alternative scenario, GNP = gross national product

[a] Assumes no change in enrollment rates for ages 5-17 and a 16% increase in the "intensity" of education which could result from a 23% increase in teaching salaries (salaries are 47% of total costs). The population in age cohort 5-17 years old increases by 9.9% between 1983 and 2005.

[b] Assumes private/public ratios remain unchanged following long-standing trends.

[c] Assumes no changes in participation rates for cohorts aged 18-29. Spending assumed to change in proportion to enrolled students aged 18-29 (a decline of 0.75%) with intensity increased 15%.

[d] Assumes no decline (equivalent to an assumption that spending in this area increases as the participating school population aged 18-30 increases, offset by a 10% increase in intensity).

[e] Assumes new participation rates for cohorts aged 30-44. Spending is assumed proportional to enrolled population with a 15% increase in intensity.

[f] Assumes a 9.9% growth because of increase in school age population. Intensity increases to 4,000 per student. This could be achieved with a $500/year per student charge for capital equipment, a student teacher ratio of 30 and students spending 25% of their time on computers or other equipment. It could also be achieved with a student teacher ratio of 20 and students spending 50% of their time on computers or other equipment. See U.S. Congress, Office of Technology Assessment, "Education," sector study, 1987.

[g] Spending scales with population aged 18-29 with assumption of higher participation rates. Intensity increases 15% as the result of growing use of computer based equipment in the 3% growth case but does not increase in the case of 1.5% growth.

[h] Assumed to scale with population aged 30-44 with high participation rates. In the 3% growth case, intensity is assumed to double.

SOURCES: 1983 data on spending in major categories from U.S. department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, July 1987; teaching costs for 1983 are computed by dividing the total expenditures for 1963 shown in the National Income and Product Accounts by total enrollment in elementary and secondary schools and higher education provided by the Office of Educational Research and Improvement, U.S. Department of Education, in *Digest of Education Statistics 1987*, Washington DC, 1987.

In addition to these three categories of instructional staff, there is a group of teachers who at present specialize in various activities such as teaching the handicapped, or providing special tutoring in music, art, or library assistance, perhaps in one school but sometimes in a number. These specialized teachers would be integrated in the above categories. It is assumed that information technology can be made available at an amortized cost of $500 per year per work station.[157] Obviously, there are a large number of ways to allocate student and teacher time given the alternatives suggested here. These new strategies are consistent with a significant increase in staff salaries. (see the appendix for details).

PERSONAL BUSINESS AND COMMUNICATION

The category "Personal Business and Communication" combines two related activities. The first, communication, involves the transfer of messages now accomplished through telephone and mail. The second, personal business, covers insurance, legal assistance, banking, and a variety of other activities that rely heavily on these message services. Both activities center on the processing of information, and improvements in information technology are having a profound effect on both.

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[157] This estimate is derived from the informal consensus of the group participating in OTA's workshop; see *Information Technology and Its Impact on American Education*, op. cit., footnote 148.

Demand for Communications and Information

In general, new communication technologies like the telephone have come in addition to, and not as substitutes for, existing communication channels. News and information received on television complements rather than replaces information in magazines and newspapers. New technologies, however, are confusing the situation by creating a number of intermediate steps between "broadcasting" a message to a broad audience, and communicating a specially tailored message "point-to-point."

Anticipating the way consumers will react to the myriad of new communication products and services likely to be offered during the next few years is virtually impossible, if only because very little is actually known about what individuals need information for or how much they are willing to pay for it. This is partly because much of the information available to individuals is provided by advertisers at little or no monetary cost, although the cost in terms of the time needed to absorb such information can be high. The uncertainties have led some very sophisticated companies into some disastrous investments. The following paragraphs sketch out a few basic facts about residential information markets.

Table 3-30, for example, shows how first class mail is used. Of all 1986-87 first class mail received by households, 80 percent involved a transaction of some kind, and nearly 50 percent involved bills, invoices, and payments. The remaining 20 percent involved personal correspondence. First class mail is responsible for roughly two-thirds of U.S. Post Office revenues.

Demand for first class mail is quite inelastic. A 10 percent price increase in the first class rate is likely to have a negligible effect on volume, and therefore is likely to produce a 10 percent increase in revenue. The other mail classes, even though subsidized by first class, are subject to competition and sensitive to price increases.

Telephone prices have fallen in real terms for more than 30 years. Between 1950 and 1982, for example, the cost of telephone and telegraph services measured in current dollars increased by 213 percent while the cost of all products in the economy increased by more than 350 percent. There is no reason to expect that this pattern will be broken, since a variety of new technologies are available for reducing communication costs. And because the elasticity of demand for telephone service is high, new technologies can be expected to lead to significant increases in the volume of telephone traffic. Enhanced services, however, are likely to change the nature of telephone service in qualitative ways, and prices may increase to cover these enhancements. The question of whether the cost of the basic service will also increase depends on the extent to which regulatory authorities permit regional holding companies to include the cost of enhanced service in their basic rates.

Table 3-30.—The Distribution of First Class Mail, 1986-87 (received by households)

Mail by type	Percent
Personal correspondence from a friend or relative	17.9
Personal letter	(6.3)
Holiday/season's greeting card	(6.5)
Other greeting card, invitation, announcement	(5.2)
Business	80.9
Bills, invoices, receipts	(46.4)
Advertisement, notices, etc.	(18.1)
Other	(16.4)
Don't know/no answer	1.2
Total	100.0

NOTE: The category of "other" includes such items received from private businesses, government, or social, charitable, political, or nonprofit groups that are not elsewhere classified (as well as educational acceptances and report cards). Annual totals compiled by adding totals for the first three quarters of postal year 1986/87, and approximating data from the fourth quarter (6/8/87-9/28/87) by doubling the totals of the third (3/16/87-6/7/87). Sample size over three quarters—20,713 weighted pieces.

SOURCE: U.S. Postal Service, Demand Research Division, September 1987, unpublished.

Market fragmentation is clearly having a major effect on telephone service. At the end of the 1970s, virtually every household in the country had the same "plain old telephone service" (known as POTS). Today there is a proliferation of home telephone devices and a slowly growing range of services (most now marketed to the home through 900- or 979-services, providing everything from stock market information to dirty jokes). Portable telephones, redial features, and cellular telephones are entering markets once limited to the standard handsets available from AT&T. At least 10 percent of American homes now have answering machines, sales of which increased at a compound rate of 34 percent between 1980 and 1984.[158]

Future competition for the point-to-point message service is likely to be dominated more by improvements in quality than by reduction in the price of basic services. There is no good vocabulary for measuring the "quality" of communication, but at least four categories suggest themselves: timeliness, accessibility and convenience, presence, and the maintenance of an archival record.

The situation will become more complex as the new technologies introduce a range of intermediate services between "point-to-point" communication and broadcasting. Consumers are already being besieged by computer-generated "broadcast" telephone calls. Catalogues and even the editorial content of magazines are being tailored to specific regions, demographic groups, and marketing groups. Many businesses and universities are experimenting with "narrowcasting" training sessions, announcements about policy changes, and other business communications. Cable television and VCR rentals are fragmenting the broadcast of television programming, allowing access to more specialized and narrower markets.

Countering this trend toward geographic and demographic targeting is the growth of "national" newspapers. *The Wall Street Journal* and Gannett's *USA Today*, transmitted by satellite to distribution points throughout the country, reached a circulation of two million in 1985.[159] Direct marketing is thriving on a system in which data about products is broadcast through television, and catalogues are sent by third class mail with customers making purchases through 800-number telephone calls. Rather than broadcast data through publications, database systems permit users access to highly specific data.

There are a large number of potential applications for new kinds of point-to-point communication services. However, few of them can be realized with the existing state of technology available in the home, and few can by themselves justify the introduction of advanced technology—although increased use of home satellite dishes and cellular telephones has in part resulted from demand for such services. High-speed communications will continue to enter individual residences because of a market for broadcast or narrowcast entertainment and news programming.

If a significant fraction of the cost of the system can be attributed to this function, point-to-point services available to the home can be delivered at a lower marginal cost than that of services of equivalent quality, and growing markets can be discovered. Financial, technical, regulatory, and marketing problems have prevented these systems from offering anything but the most basic re-broadcast services, and it is unlikely that existing cable networks can evolve into a multi-purpose information system capable of delivering point-to-point communication services in the form of voice or data communications.

Sophisticated residential communication services will almost certainly be provided by an organization associated with existing telephone companies. Applications might include:

- **Home Banking and Bill Paying.** To date, there has been more talk than action in home banking. At the end of 1986, there were about 100,000 home banking installations. Most of them are operated by individuals who have already invested the time and money needed to become familiar with home computers, and who are willing to pay $5 to $20 a month for the privilege of instant access to transactions. But demand could increase rapidly. In addition to simple checkbook accounting, the systems could be given a variety of features such as sorting and documentation for home records and tax purposes. Still more sophisticated systems could offer complex financial services and ready access to financial information. A recent survey by the insurance industry concluded that most households would be pleased to order insurance at home over computer lines and to make claims through electronic mechanisms, instead of filling out tedious forms.
- **Home Health Care.** Increasing pressures to get patients out of hospitals lead to a growing need for communication between homes and health care facilities. Microprocessors can provide assistance in scheduling the administration

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[158] Pacific Telesis Group Voice Storage and Retrieval (VSR) Information Services, July 11, 1986, cited in P.W. Huber, *The Geodesic Network* (Washington, DC: U.S. Government Printing Office, 1987).

[159] Arlene K. Fleming and Robert S. November of LINK, Inc., "The Impact of Technology on Home Information, Transactions, and Entertainment," contract report prepared for the Office of Technology Assessment, June 1985.

of drugs at home, and can also monitor dosage to eliminate undesired combinations of medication. Physicians, acting with the assistance of visiting nurses, nursing home staff, and the patients themselves, can use equipment located in a patient's home and even devices implanted in the patient's body, such as pacemakers and implantable pumps, to monitor the progress of a patient.

- **Residential Controls.** Home energy systems capable of scheduling residential electric demands to minimize system costs have already been described. Other systems that could be coupled with the network include security systems, pay-per-view television ordering, and other applications.
- **Information Services.** Systems creating an easily accessible, nationwide database have already been instituted in France, Japan, and several other nations. The absence of a government supported program, coupled with a ban preventing the Bell Operating companies from offering information services, is at least partly responsible for the fact that home information systems have moved much more slowly in U.S. markets than they have elsewhere.
- **Home Shopping Services.** The growing volume of catalogue shopping resulting in part from a decline in available time, suggests that a market may exist for electronic shopping at home. A variety of projects are under consideration including the ambitious Trintex system conducted as a consortium of Sears, CBS, and IBM.

The French national telephone company appears to have succeeded in introducing a nationwide information network in that country by distributing inexpensive terminals to their customers. The system provides access to the 23 million listings of the French telephone system as well as more than 4,000 privately offered information services billed through the telephone system.[160] Services include an electronic newspaper, classified ads, bulletin boards, home shopping, a dating service, etc. About half of the subscribers reportedly use home banking and 24 percent use the home shopping service on a regular basis.[161] The information services are billed at rates varying from 5 to 10 cents per minute of use. There were 2.24 million "Minitel" terminals operating at the end of 1986, with an average rate of use of 97 minutes per year per terminal.[162] The total number of terminals has doubled in the past year.

The French claim that the system is now profitable. Telephone information services provide approximately 17 percent of total revenue. The remainder coming from private service firms using the Minitel system as a vehicle for reaching residences.

Japan, Germany, Canada, and England have had similar experiments with much less spectacular results. The Japanese are experimenting with a 3.5-inch floppy disc now available with the entire four-volume Tokyo telephone directory. In one second, this disc can provide listings for 9,170 sushi restaurants in Tokyo, and can then narrow the choice based on geographic vicinity.

Keytron, Viewtron, and other efforts to introduce videotext services in American markets resulted in expensive failures. In contrast to the centrally planned experiences abroad, however, the regionalization of American industry makes it likely that locally arranged formulas, which accord to the specifics of local markets, could be more successful than a single national program.

Demand for Business Services

Demand for personal business services is being reshaped by increasing consumer sophistication and a rapidly changing regulatory environment. Demand is becoming more fragmented as technology and affluence permit greater choice; it is also becoming more homogeneous in areas where technology permits economies of scale in the sale of standardized products. Changes under way in life insurance provide a vivid example.

Traditional whole life polices combined three kinds of products: investment, risk coverage, and financial service. In the parlance of the industry, these products have become "unbundled." Higher-income individuals interested in investments now look to other financial instruments, which offer greater liquidity, more flexibility, and higher returns. They also look elsewhere for more comprehensive financial services. Low- and middle-income individuals interested primarily in risk coverage now look increasingly to standardized, simple, and inexpensive insurance that provides no "thrift" or savings value.

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[160] *Telematique News*, Paris, spring 1987.

[161] P.W. Huber, *The Geodesic Network*, report prepared for the U.S. Department of Justice, Antitrust Division (Washington, DC: U.S. Government Printing Office, January 1987).

[162] J. Grenier and G. Nahon. "France Wins Big With Its Minitel Videotext System," *Telephony*, July 27, 1987, pp. 46-49.

As a result of these changes, premiums for whole life policies fell from 76 percent of all premiums in 1950 to 42 percent in 1982, while cheaper term insurance, providing no savings, grew from 41 percent of all life purchases in 1960 to 59 percent in 1981.[163] Comparatively inexpensive group products, which represented 30 percent of insurance in force in 1960, grew to 46 percent by 1982. Consumer savings have moved sharply away from life insurance, commanding only 3.4 percent of individual assets in 1980 as opposed to 5.9 percent in 1960.[164]

Demand for property/casualty insurance grows roughly in proportion to the number of things to be covered—primarily houses and automobiles. These businesses have become highly competitive and offer highly standardized products inexpensively. Some are sold through "financial supermarkets," offered by companies as diverse as Citicorp and Sears. The conversion of a product to a commodity does not necessarily reduce the quality of services offered. Clerks in local offices now have access to semiautomatic underwriting and claim review systems, allowing them to enter information directly from a local office or even the field, where a portable computer can be used in claims examination. The time required to process applications and process claims can be greatly reduced. The price of policies can be expected to decrease as automation substitutes for the current inefficiencies of the insurance system, which are being eliminated rapidly as intense competition forces an unprecedented examination of costs.

Choices and Consequences

Spending on communications for home use will be highly sensitive to technical developments throughout the economy and to programs designed to facilitate high-quality communication to the home. Table 3-31 explores some scenarios. The Alternatives assume a continuation of the rapid decline in prices and improvements in the range of service quality and variety.

Table 3-31.—Consumption Scenarios for Personal Business and Communication (billions of 1983 dollars)

		2005			
	1983	Trend 3%	Trend 1.5%	ALT 3%	ALT 1.5%
Telephone	37.9	78.7[a]	66.2[a]	111[b]	92[b]
Stationery	5.8	11.1[c]	8.0[c]	11[c]	8[c]
Personal Business	132.5	282.9[a]	171.3[a]	333[d]	201[d]
Total PCE	176.2	372.7	245.5	455	301
Government	0.7	1.3	1.0	1.3[b]	1[b]
Total	176.9	374.0	246.5	456	302.0
Percent Share of gross national product	5.2	5.7	5.2	7.0	6.4

ABBREVIATIONS: ALT = alternative scenario, PCE = personal consumption expenditure

[a] Follows extrapolative technique described in Chapter 2.

[b] The trend scenario assumed a 20% decline in the real cost of telephone communication and a price elasticity of −1.12. The ALT 3% case assumes a 40% decline in costs following a trend in communication equipment. It is also taken to be the reduction in cost of information processing equipment likely to constitute a major part of spending in the "telephone" category during the next 20 years.

[c] Assumes that spending in this category is the same proportion of total Personal Consumption as it was in 1983 for all scenarios.

[d] Arbitrarily increased by 15% to include charges of a variety of home information and business services ranging from consumer marketing to financial services.

SOURCE: Office of Technology Assessment, 1988.

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[163] American Council of Life Insurance, "Life Insurance Fact Book," 1983.

[164] Ibid.

RECREATION AND LEISURE

Increased household income, coupled with decreasing amounts of free time, have reshaped American leisure habits. Many of the changes are difficult to document with precision. For the purposes of this discussion, recreational and leisure spending include:

1. use of the media (now largely within the home) —this includes reading books, newspapers, and magazines; listening to the radio, records, and tapes; and watching television;
2. participatory sports, spectator sports, and club functions (including welfare and religious activities), which usually take place away from home;
3. traveling for pleasure and vacations—spending for domestic transportation is included in the transportation amenity discussion, but all other expenses (such as hotels and amusements) as well as foreign travel are included in these accounts.

The definitions are thus guided by expenditure categories. But it is obviously a mistake to conclude that demand for recreation can be reduced to spending on related products and services. Recreation and Leisure also includes considerable non-market activity—participation in certain religious, professional, political, or athletic activities, for example, and informal social visiting among family and friends. Changes in the way Americans use their leisure time were discussed in the previous chapter. Having more money to spend on recreational activities does not necessarily mean that free time is being better used; and it certainly does not mean that there is more free time available.

Recent Trends

A number of often paradoxical trends are notable in this complex economic sector, one in which changing demographic factors and social trends makes the past an unreliable guide to the future. These include:

- a squeeze between decreasing usable leisure time and increasing costs of recreational activities;
- partial displacement of mass-production leisure products and services by more differentiated (and more expensive) specialized ones, resulting in parallel mass and differentiated economies in some fields;
- a lack of clear movement from outdoor to indoor recreation; in fact, media and participatory activities in some ways reinforce each other as well as competing for time and money;
- a growing diversity of activities with a high degree of specialization, each involving its own media, equipment, clothing, and social organizations;
- burgeoning demand for convenient, close-to-home, or short-term recreations, which fit into increasingly complex personal schedules;
- growing competition for mass media as targeted advertising and pay-per-view media drain revenues that currently subsidize inexpensive or "free" media like newspapers and broadcast television—alternatively, the "new" media could complement the old in another parallel mass/differentiated dichotomy;
- a potential split between overcrowded, deteriorating public recreational facilities and expensive, specialized private ones. (The pressure for "user fees" to replace public funding of facilities—including parks and public libraries—could widen the existing economic/educational gaps in enjoyment of recreational variety.);
- keen competition in some recreational fields, producing superior products and service with better employment opportunities at only slightly increased cost to the consumer—for instance, formerly exotic cuisines are increasingly available to all, just as more customized travel opportunities abound;
- growth in recreational businesses catering largely to childless couples and young singles as well as to seniors who are healthier, more affluent, and more knowledgeable than in the past, and fuller participation by minorities and handicapped Americans in the whole range of recreation available;
- the difficulty of single-parent families and less

educated people to have full access to recreational opportunities. The entry of more and more women into the labor market particularly alters the nature of recreational demand;

- a need for greater "leisure literacy" to enable the whole population to take best advantage of multiplying opportunities the way many of the most affluent and educated do now, in spite of tightly scheduled personal lives; and
- opportunities for the United States to exploit its domestic advantage in the Recreation and Leisure sector while increasing its export revenues.

There has been a rapid increase—more than 5 percent per annum—in spending on Recreation and Leisure over the past 23 years. This general rise conceals several contrasting developments. Expenditure on books, newspapers and magazines, and spectator amusements (such as the movies, theater, and sports events) rose moderately (between 1 and 2 percent a year), while expenditures on sports equipment and other entertainment services (such as sports clubs and golf courses) rose rapidly (between 6 and 7 percent annually). There was a particularly sharp rise in purchases of radio, television, and other electronic devices (more than 10 percent), whereas expenditures on repairs rose slowly—testifying to improved quality and reliability. The two vacation items—hotels and overseas travel—rose at 4 percent annually, faster than total personal consumption expenditures but not so fast as some other elements of Recreation and Leisure (see figure 3-8 for more detail on these trends).

The trends suggest that demand in this sector is primarily for goods rather than services. Americans are devoting more of their Recreation and Leisure dollars to new media technologies. Much of this development has been driven by electronics technology. To the degree that most Americans enjoy spectator sports, theater, concerts, and other forms of art and entertainment, they are increasingly able to do so by means of the mass media.

This is confirmed by patterns of expenditures on spectator amusements. The share of these amusements in the total, while never large, dropped from 10 percent in 1960 to about 4 percent in 1983. Expenditures on movie theaters actually declined in certain years, reaching a low in 1975 that was 65 percent of the 1960 level. While there has been some later recovery—many movie theaters have adapted to rapidly changing consumer demand by increasing the number of films shown at any one time or serving refreshments at one's seat—spending at movie theaters grew a miniscule 5.1 percent between 1960 and 1983.

In contrast, there has been spectacular growth in spending on television and home electronics. According to one survey, the percentage of consumer media spending allocated to new electronic media—cable and pay TV, video cassette recorders (VCRs), video games, and home computers—rose from 7.5 percent in 1978 to 30.8 percent in 1982.[165] In the late 1970s, growth was concentrated in cable television; by 1984, cable television revenues had reached $7.5 billion.[166]

The early 1980s were also the era of the video game. In 1981, video game arcade users spent $5 billion—equal to the combined revenues of the Las Vegas gambling industry and the U.S. film industry, or the total television revenues and gate receipts of major league baseball, football, and basketball.[167] In 1982, this figure rose to $7 billion—greater than the combined revenues of the movie and record industries. Demand for video games began to slacken in 1983, but electronic media spending was buoyed by yet another enormously popular product—the VCR.

So far, the VCR has followed the classic growth curve of innovative home electronic products; the first eight years of VCR sales parallel almost exactly the growth years of color television.[168] In 1985, consumers spent between $2.3 and $4.5 billion to rent and purchase video tapes.[169] By 1986, movie industry revenues from video-cassette sales equaled revenues

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[165] Ronald Rice, "Development of New Media Research," in Ronald Rice and Associates, *The New Media: Communication, Research, and Technology* (Beverly Hills, CA: Sage Publications, 1984), p. 16.

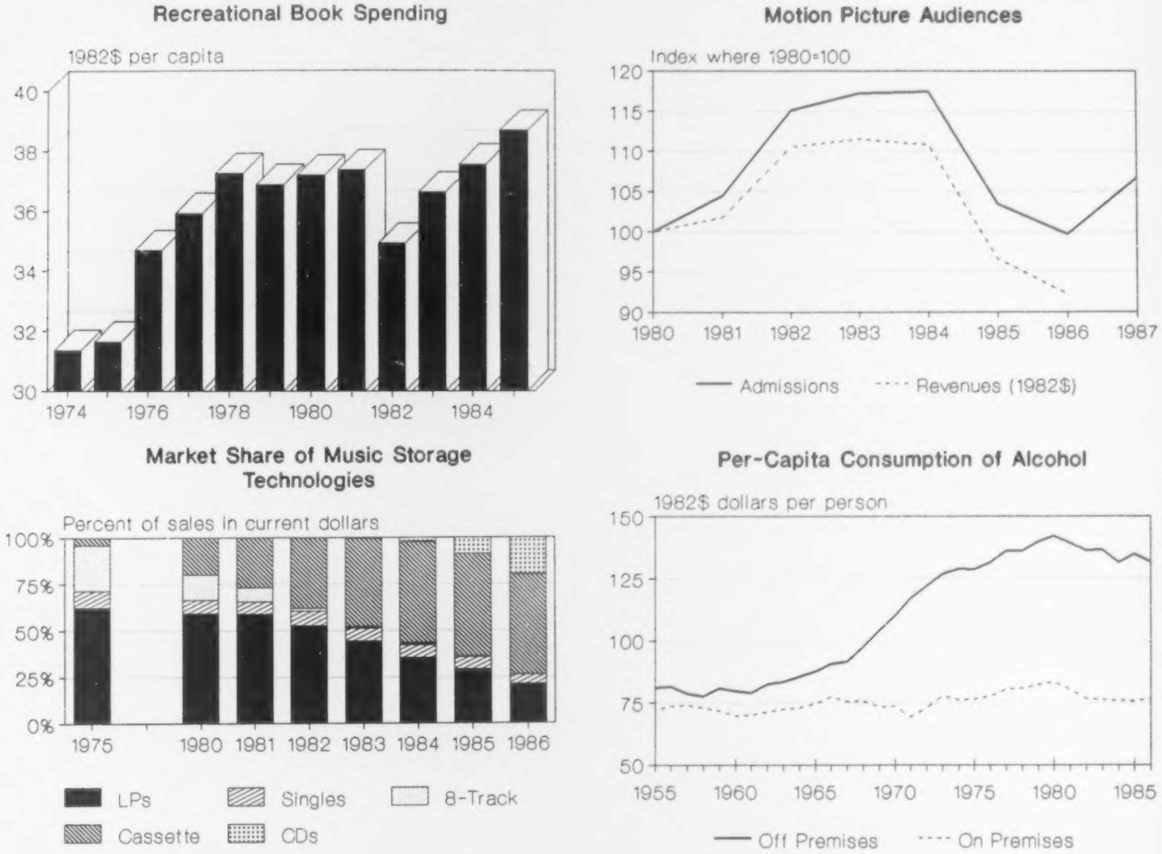
[166] Rushworth M. Kidder, "Videoculture: TV—for Better or Worse, a Window on the World," *Christian Science Monitor*, June 10, 1985, p. 20.

[167] Ronald Rice, "New Media Technology: Growth and Integration," in Rice and Associates, op. cit., footnote 165, p. 66.

[168] David Lachenbruch, "Home Video: Home Is Where the Action Is," *Channels of Communication—1984 Field Guide To the Electronic Media*, p. 42.

[169] Aljean Harmetz, "Studios Woo Cassette Mass Market," *New York Times*, Feb. 27, 1986, p. C26.

Figure 3-8.-The Leisure Industry, 1986



NOTE: Deflator for "admissions to specified spectator events" used to convert motion picture admissions to $1982.

SOURCES: U.S. Bureau of the Census, *Statistical Abstract of the United States: 1987* (107th edition), Washington, DC, 1986, tables 368 (recreational books) and 372 (music technologies); U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 2.4 (motion picture revenues) and 2.5 (alcohol consumption); Motion Picture Association of America, New York, NY for admissions. Motion Picture revenues and recreational book spending converted to 1982 dollars using table 7.10 of the "National Income and Product Accounts." Categorization based on "Leisure Statistics," *The Wall Street Journal*, Apr. 21, 1986, p. 13D.

from box office movie sales. Approximately one-third of American households already own a VCR, and estimates suggest that VCR penetration will reach 50 percent by 1990.

These developments owe much to increases in income coupled with falling prices. Over the past 23 years, prices for television and audio entertainment have declined 60 percent in constant dollars. Moreover, the most recent forms of electronic equipment have entered the market at relatively low prices, ensuring rapid market penetration. Prices of sporting equipment have also declined sharply, accounting for part of the particularly rapid increase in purchases of these items.

Changes in disposable time have interacted with these developments. Studies of the way people use their time show a sharp decline in the amount of free time available, especially in the past 10 years. This places a premium on home entertainment, such as running a movie on the VCR or seeing a sporting event on a large screen, rather than on spending extra hours in transportation to entertainment centers outside the home. This, in turn, further diversifies demand for recreational activities that can serve the particular tastes and needs of individual consumers—activities being improved by technologies that permit greater flexibility in response to consumer demand.

Choices and Consequences

In the area of electronic entertainment, there seems every reason to believe that market penetration by some of the more recent technologies, such as compact discs, cable television, and VCRs, will continue. The development of such new technologies as video discs and high-definition television will also improve the quality and range of entertainment (and other information activities) within the home. New developments will combine the telephone and personal computer—at present, mainly designed for social contact and personal business—to provide a variety of information and entertainment services. The development of such new technologies as video discs and high-definition television will also improve the quality and range of entertainment (and other information activities) within the home entertainment centers; there is every reason to believe that these innovations will eventually become available to consumers at reasonable cost. The French "Minitel" hookup, originally designed to give consumers more efficient telephone service and buy them time through efficient transaction of business, has won widespread acceptance through its adaptation as a recreational device. Despite regulatory differences, an American system or systems could take advantage of similar consumer demand.

A substantial part of Recreation and Leisure activities, such as ski centers, golf courses, sightseeing buses, and hotels are still labor intensive. This fact has accounted for a past increase in relative costs. If new information technologies permit improvements in labor productivity, these costs could decline in the future. Yet demand for better services could produce a generation of recreation or hospitality professionals to enhance the consumer's experience.

Two related factors, demographic trends and available time, will also influence expenditure. The ability to enjoy leisure and recreation needs a combination of time and money. If time is in short supply, leisure may be curtailed regardless of money, or at least recreation expenditures may be channelled into directions that save time. The growing complexity of family schedules fuels demand for convenient, close-to-home recreation and shorter—though perhaps more frequent—vacations.

The time budget data referred to in chapter 2 serve as a basis for a rough estimate of future trends in leisure time. It is first assumed that disposition of time for both men and women in 2005 will be the same as in 1985. In this case, free time—time which is not spent on work, traveling to work, housework, personal care, and eating—will increase by about 25 percent between 1985 and 2005. The largest portion of this increase, 21 percent, is due to the rise in population, and the balance to an older population that will include a greater share of retired people. Individuals, however, may find themselves more pressed for time than ever.

On the other hand, there may be changes in the way time is spent. Time budgets of 2005 may well be different than those of 1986. A 10-percent reduction in the work week occasioned by improved technology could increase the hours of free time available by 6 percent, while a halving of the time devoted to shopping due to improved information technology could increase free time by 5 percent. If, in contrast, the rising participation in the labor force—which caused the reduction in leisure time between 1975 to 1985—continued, the amount of time available for leisure and recreation would fall.

Household formation is also of importance. The share of young single people, who spend more of their income (and higher absolute amounts) on recreation, will decline, thus tending to depress Recreation and Leisure expenditures. A countervailing factor, however, is the expected increase in childless households, traditionally high spenders on recreation. Furthermore, the "new" elderly, a rising share of the population, may spend more on Recreation and Leisure than their present day equivalent.

The future, therefore, offers mixed prospects. On the one hand, the abundance of leisure activities and cultural opportunities potentially available is the greatest in history. There will be an unprecedented selection of destinations, books, entertainment, sports, media, and cuisine. As new technologies enhance flexibility in consumer choice while helping to reduce prices, the information necessary to personalize fulfillment of leisure needs and opportunities may soon be within the reach of all.

On the other hand, not all Americans may be able to share in these riches. Household expenditure data suggest that there are many families too poor to take advantage of recreational activities. Single parents, for example, spend virtually nothing on travel or entertainment. Emerging fee-for-service media may drain advertising revenue from traditional publishing and broadcasting, depriving the less affluent of much affordable or free information and entertainment.

Scenarios are described in table 3-32.

Table 3-32.—Consumption Scenarios for Recreation and Leisure (billions of 1983 dollars)

		2005			
	1983	Trend 3%	Trend 1.5%	ALT 3%	ALT 1.5%
Entertainment services	58.2	154.3[a]	81.1[a]	183[b]	97[b]
Entertainment commodities	62.4	149.8[a]	104.9[a]	165[b]	115[b]
TV and sound	31.4	87.6[a]	61[a]	106[b]	78[b]
Lodging and foreign travel[c]	22.2	64.9	37.7	84[b]	51[b]
Religious and welfare[d]	47.6	91.2	65	119	86
Total PCE on recreation and leisure	221.8	547.8	349.7	657	427
Government purchases of recreation and leisure[e]	8.6	16.5	11.9	20	13
Total	230.4	564.3	361.6	677.0	440.0
Percent share of GNP	6.8	8.7	7.7	10.4	8.3

ABBREVIATIONS: ALT = alternative scenario, GNP = gross national product, PCE = personal consumption expenditure

[a] Follows Extrapolative technique described in ch. 2.

[b] Alternative estimates of demand for entertainment services, entertainment commodities, and tv and sound equipment are above those computed in the trend analysis for reasons discussed in the text. The increases are constructed by assuming a price reduction in the items that is more rapid than the one used in the trend case. The price of entertainment services is assumed to fall 15%, entertainment commodities 30%, and TV and sound equipment 40%.

[c] In the period 1960-72 real expenditures on foreign travel increased 48% faster than all PCE. After 1972 there were wide variations in spending reflecting swings in exchange rates. Extrapolation is clearly difficult. In the estimates shown it has been assumed that foreign travel will continue to grow at roughly the 1960-72 rates. It has therefore been assumed that spending in this category would increase 4.44%/year if GNP grows 3%/year and that spending would increase 2.2%/year if GNP grows 1.5%/year.

[d] Assumes that spending in this category is the same proportion of total PCE as it was in 1983 for all scenarios.

[e] Government purchases assumed to be in proportion to personal consumption.

SOURCE: Office of Technology Assessment, 1987.

Part II

The Networks of Production

Understanding how changing patterns of consumer and government purchases translate into demand for output from specific businesses is a heroic challenge in a modern economy. Products once brought to consumers through direct and obvious channels are now provided through networks of extraordinary complexity. In the 19th century many Americans lived on the farm. They produced most of their own food and, with the exception of an occasional purchase from a blacksmith, were essentially self-sufficient. Today, not only have farms become specialized, highly capitalized, and technologically sophisticated, they have become comparatively minor elements in a sophisticated network of businesses delivering the "Food" amenity to consumers. This section describes the operation and performance of these production systems in a modern economy, and speculates about how they may change in the future.

The growth of linkages connecting diverse parts of the economy helps explain the explosive growth of sectors other than traditional manufacturing. A packaged frozen pizza may combine produce picked and processed in California, sophisticated packaging materials made in Michigan, and a paper label manufactured in Washington and printed in Illinois, as well as financing from Chicago, advertising and legal services from New York, trucking from independent truckers throughout the Nation, inventory control and billing software from Palo Alto, and communication systems from New Jersey. The "service" businesses play a growing role in getting pizzas to American plates. Among other things, such businesses facilitate the billions of transactions that connect elements of production networks, make it possible for firms to redesign their operations quickly in response to new market opportunities and changes, and allow production networks to make and deliver products and services more precisely targeted for the increasingly diverse markets described in Part I.

Increasingly, networks of production also involve foreign producers and consumers (the topic of Part III). Tightly integrated networks create a situation where the effects of international trade are felt far beyond the sectors actually engaged in trade. Imports that displace U.S. manufacturing output, for example, also reduce output in a constellation of nonmanufacturing enterprises linked to manufacturing —such as banking, insurance, and business services.

The complex networks that connect producers to consumers in the American economy have become so elaborate that it is difficult even to determine how and where value is added in the process of delivering useful products and services to final consumers. Yet most of the important changes taking place in the American economy can only be understood by observing the integrated performance of these networks operating as a whole. In such a situation it is easy to be misled by asking the wrong questions. It is entirely possible, for example, that firms appearing to enjoy productivity gains may perform poorly within a dynamic and flexible network. A firm that depends on mass production and great certainty about future markets to ensure low costs may have difficulty in a world where products and production strategies are in constant flux. Certainly, any attempt to improve network performance through public policy now requires a system-wide perspective to ensure that changes actually help, rather than frustrate, the emergence of efficient networks.

Driven by new technologies, the pressures of foreign trade, new patterns of demand, and a changed regulatory environment, profound changes are sweeping through virtually every major business network. Even those that have resisted change, such as residential construction and education, may be on the brink of major change. The next three chapters provide a description of trends in the performance of the eight major networks that deliver amenities to final consumers and suggest possibilities for future patterns of change. Chapter 4 provides some basic tools for describing the integrated performance of these networks. Chapter 5 uses these tools to examine recent patterns of change. Three kinds of change are examined:

1. **Changes in the "production recipe," or the mix of goods and services a business uses to make its product.** Virtually every such recipe involves proportionately less natural resources and more "transactional" serv-

ices like banking and legal help. And nearly all production recipes are growing in complexity, increasing the links connecting one part of the economy with another.

2. **Changes in the internal management of businesses, and in the way businesses connect to form production networks.** Generalizations are difficult. It appears that highly fragmented structures (elements like small farms, homebuilders, or family physicians) are increasingly becoming parts of larger enterprises, while firms that had concentrated production in a few establishments are turning to smaller facilities and purchasing more inputs from other businesses. In an increasing number of cases, a few dominant firms set de-facto standards and serve, indirectly, to organize activity.
3. **Changes in the geography of production.** The growth of activity outside of traditional manufacturing and the vast increase in communications technology offers the potential to decentralize production in ways never before considered possible. In general, however, this potential has not been realized, and economic activity increasingly accumulates in and around major urban centers—particularly those on the east and west coasts.

Finally, chapter 6 pursues these themes through the eight major amenity networks discussed in chapter 3. Each, of course, has a unique story to tell. Taken together, they can provide a perspective on structural change in production that cannot be obtained from an examination of economy-wide statistics.

Chapter 4

Defining the Production Recipe

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Chapter 4

Defining the Production Recipe

The first chapter of this volume proposed a strategy for understanding how complex networks of activity in a modern economy connect work with amenity. The first step in this process (undertaken in Part I) was to convert demand for amenity into demand for output from specific industries. The second step (the task of the present chapter) is to describe the "production recipe" that U.S. businesses use to create these goods and services. The accounting method employed to perform this calculation is commonly called "input/output" analysis. Part IV will examine how these outputs translate into jobs.

A concrete example can help to introduce the basic concept and the somewhat baroque vocabulary used in the accounts. One way to begin is by asking where a customer's money goes when he buys a frozen pizza. The pizza was made in a factory that ships products to a grocery outlet through a series of intermediaries. The sales price can be divided into two categories: one that generates business for the pizza factory; and another that goes to pay for the insurance, transportation, wholesale, and retail businesses involved in getting the pizza from the factory to the grocery store shelf. These latter costs are called "margins."

The question then becomes one of determining the business recipes used by the pizza factory and by the enterprises that provide the "margins." These recipes consist of two parts: intermediate inputs and value-added. The "intermediate inputs" are purchased by a firm from other businesses. For the pizza company this might include ingredients like flour and tomatoes, as well as the advertising, accounting, and legal services needed to conduct business. The difference between the revenue received by selling pizzas and the cost of the intermediate inputs is the "value-added" generated by the pizza firm. This value-added consists of salaries paid to employees, "indirect business taxes" (like sales taxes), and profits.[1] A business recipe of this sort can be constructed for the grocery store where the pizza was purchased, the wholesale operations that supplied the store, and the insurance company and trucking firms that provided other needed services.

This is, however, not the end of the story. The "intermediate inputs" purchased by the pizza firm in turn generate demand for other products. Purchased flour, for example, generates demand for farm production. Farming generates demand for fertilizer. The purchase of a pizza therefore generates "indirect" demand for the products of the chemical firms that produce fertilizer. Since both the farms and the chemical fertilizer firms have "intermediate input" expenses as well, they retain only a portion of the consumer's dollar as value-added. The challenge, then, is to trace the consumer's dollar through this elaborate network of activities in a way that avoids double-counting. A $5 frozen pizza can only generate 5 dollars' worth of value-added in the economy. A complete set of production recipes (one that covers all parts of the economy) can be used to estimate the output in each business created by different patterns of consumer and government purchasing using "input/output" analysis (see box 4-A).

The remainder of this chapter uses this method to show how consumer purchases result in activity throughout the U.S. economy. It proceeds in the following steps. First, it assigns each business operation to one of 10 "production sectors." This is done so that broad shifts in production recipes can be illustrated. Second, it shows how consumer purchases in different amenity categories translate into demand for different types of business activity (including an estimate of the margins). It then turns to a discussion of the production recipe for each major business type and explores recent trends in the "intermediate inputs" required. Finally, it uses input/output methods to calculate the direct and indirect consequences of different types of purchasing. The techniques can be used to show how spending for each amenity category generates value-added directly and indirectly in all areas of the economy, and how the economy is becoming increasingly interconnected.

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[1] More precisely, "value-added" shown on the input/output tables includes the following categories: employee compensation (a category that includes wages, salaries, and employer contributions for such purposes as pensions and health plans), property type income, and indirect business taxes (a category that does not include corporate income tax). For more detail on employee compensation, see ch. 11.

Box 4-A.—Input-Output Analysis

The logic of input-output accounts has been recognized since 1758, when they were published as a "Tableau Economique" by Francois Quesnay, the French economist. Refined and applied to the U.S. economy by Wassily Leontief in the late 1930s, input-output accounts (I-O) form the foundation of most modern econometric models. Leontief was later awarded the Nobel prize in economics. Input-output accounts are used by approximately 70 countries. They incorporate data from all Federal industry censuses and nearly 100 other data sources.[1]

I-O accounts are not economic models in the common sense of the term. Rather, they provide a mechanism for displaying and manipulating a large amount of data that has been forced into a consistent format. The central feature of the accounts is a table in which each column represents the production recipe for an industry. In effect, this table represents a series of linear equations that can be solved simultaneously to convert a pattern of final demand to industry output.

While I-O accounts have the invaluable feature of making the technology of production an explicit part of an analysis, they do suffer from a number of limitations. Because the model is based on observed data, there tends to be a long lag time between the collection of data and the availability of I-O tables. A "benchmark" table for 537 business categories is published following publication of the industrial censuses, which are conducted every 5 years. The benchmark table for the 1977 I-O tables became available only in 1985. A 1980 summary and "revision" of this benchmark, published for 85 business categories and available from the U.S. Department of Commerce, is used throughout this analysis.[2]

Fortunately, later discussions will indicate that with very few exceptions, the interindustry relationships change extremely slowly. Factors that change more rapidly, such as patterns of consumer and government demand, imports, exports, and investments, are updated each year, and are incorporated in the analysis presented here.

I-O data are much more detailed for manufacturing than for service industries, which tend to be lumped into highly aggregated categories. At the detail published in the 1980 I-O accounts there is a separate category for the manufacture of metal boxes, while health, education, and social services are lumped into a single category.

The most important assumption made in I-O analysis is that of "linear," or constant, economies of scale. Unlike the myriad of assumptions implicit in elaborate econometric analyses, this assumption has the virtue of being simple and clear. Since I-O essentially represents an accounting technique, the I-O accounts force the user to construct "dynamic" characteristics of the economy—assumptions about how production recipes will respond to price changes, to new technologies, and to changes in the scale and scope of industrial organization. The burden of making changes, such as those that will appear chapter 13, thus falls squarely on the user. The links between I-O accounts and the primary data are transparent.

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[1] See W. Leontief, *Input-Output Economics* (New York: Oxford University Press, 1966); and R.E. Miller and P.D. Blair, *Input-Output Analysis: Foundations and Extensions* (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1985). For a description of data sources, see "Definitions and Conventions of the 1972 Input-Output Study," Bureau of Economic Analysis, U.S. Department of Commerce, pp. B3-B7.

[2] U.S. Department of Commerce, Bureau of Economic Analysis, Input-Output Tables, 1980, unpublished. A 1981 matrix was released in the *Survey of Current Business* of January 1987. See Appendix for the algebra of input-output analysis.

DEFINING A TEN-SECTOR ECONOMY

The analysis used throughout Part II can be carried out by grouping industries into as many or few sectors as needed. The original data that forms the basis of this report actually used 85 sectors (see the appendix), but only 9 or 10 will be displayed in the examples that follow. Summary categories are useful for keeping broad patterns of change in view. These 10 sectors have been selected as ones likely to be affected in similar ways by changes in technology, trade patterns, and regulation. The 10 sectors, and their relative shares of the U.S. gross national product (GNP), are shown in box 4-B.

Box 4-B.—The 10 Production Sectors

Description	% share of GNP[1]
1. *Natural Resources* includes the production of raw materials and energy of all kinds, including the generation of electricity. These industries were singled out to measure the impact of different kinds of economic activity on depletable natural resources, many of which are imported, and at the same time to trace the impact of substitutes for strategic raw materials.	9%
2. *Construction* is given its own category because of the unique nature and large size of construction activities, and in view of the critical role construction plays in renewing infrastructure and improving productivity throughout the economy. The highly cyclical nature of construction activities also sets this category aside from other business activities.	6%
3-5. *Manufacturing* activities have been selected because of growing concern about the future role of these industries in the U.S. economy. Significant direct and indirect linkages exist between manufacturing and the other parts of the economy. Manufacturing has traditionally been the major source of U.S. productivity growth, increasing at twice the rate of the economy as a whole between 1960 and 1983. It is also likely that wage increases in other industries can be traced to productivity growth in manufacturing. Activities within manufacturing have been subdivided into low, medium, and high wage sectors, based on the average level of annual compensation per full-time equivalent employee in 1984. This was done due to concern for the quality of jobs offered by growing and shrinking enterprises; more trade, for example, is attractive if the transactions result in the net substitution of high wage employment for low wage employment. The division by wage levels also provides groupings roughly commensurate with other areas of policy interest.	22%
3. *Low Wage Manufacturing* is clustered in the traditional apparel, footwear, and furniture industries.	3%
4. *Medium Wage Manufacturing* contains most enterprises recently tagged as "high technology," because these firms conduct significant amounts of research and employ relatively larger numbers of engineers and scientists. It includes industries such as electrical equipment, communications equipment, scientific instruments, and computers, and less technology-intensive industries such as food & kindred products.	10%
5. *High Wage Manufacturing* is dominated by traditional "smokestack" industries, such as those that produce motor vehicles, iron and steel, construction machinery, and glass. However, the high wage category also includes such technologically sophisticated industries as chemical production and aircraft manufacturing.	9%
6. *Transportation & Trade* are clustered because together they form much of the overhead associated with the physical movement of products. These activities are increasingly tied to manufacturing through sophisticated inventory control and dispatching networks. New technologies in transportation will be essential to system-wide improvements in efficiency—not so much from innovations in specific kinds of transportation or retailing equipment, but through advances in information flows that connect production with the marketplace more closely. While many of these technologies are difficult to trace, it appears that dramatic changes may occur in the near future.	19%
7. *Transactional Activities* deliver financial and information services to businesses. In 1984, the sector generated more value-added than the whole of manufacturing. The activities are clustered because, taken together, they are the most rapidly growing sector in the U.S. economy in terms of output and employment, and are associated with activities in which productivity improvements due to new information technologies could be enormous.	23%
8. *Personal Services* are selected because, with the exception of retailing, they contain most activities traditionally associated with the "service sector" of the economy: hotels, beauty parlors, and dry cleaning, for example. They also contain most activities associated with recreation and leisure—a sector that has grown rapidly in response to rising affluence among many consumers.	4%
9. *Social Services* follow a unique logic because of the involvement of government. With the exception of government "overhead" functions—the sector includes the salaries of both the President of the United States and the authors of this document—most of the activities in this sector, such as public and private health care and education, are delivered directly to consumers. In effect, social services support a human infrastructure.	14%
10. *National Defense* was separated from the "social services" of government because it is plainly affected by a unique set of factors.	2%

NOTES: The divisions of service functions are modifications of the categories used in J. Singlemann, "The Sectoral Transformation of the Labor Force in Seven Industrialized Countries, 1920-1970," *American Journal of Sociology*, vol. 83, No. 3, 1978, pp. 1224-1234. See also the discussion of alternative taxonomies in J.I. Gershuny and I.D. Miles, *The New Service Economy* (New York: Praeger, 1983). The appendix shows the industrial composition of each of these sectors in greater detail.

[1] The percentages represent the fraction of all value-added in the economy generated by the sector in 1984. They are calculated in 1980 dollars.

Finding a taxonomy that reveals rather than obscures deep structural change proves to be a significant challenge. Perceptions of change are often guided by what one chooses to measure. Take the distinction between "services" and "manufacturing." The printing & publishing industry is conventionally counted as a manufacturing enterprise, while television & radio broadcasting is not (presumably because this industry does not produce anything tangible). An individual writing news is considered a manufacturing employee if employed by a newspaper, but is not a manufacturing employee if employed by a television station.

Technology has begun to blur many traditional distinctions. Ten years ago, four-fifths of the value of a computer was embodied in its hardware, the remainder being associated with the software. Today, these ratios are reversed.[2] Complex patterns of merger and acquisition have further confused the situation. General Motors earned more than one-quarter of its profits in 1985 from its finance division, GMAC, the Nation's single largest holder of consumer debt. Does that make GM a service industry?[3] Chapter 6 will provide many other examples.

MARGINS

The cost of wholesale and retail trade, transportation, and insurance can add a significant amount to prices paid by consumers. In some areas, such as clothing, such margins can reach more than 50 percent of the total consumer price.[4] Moreover, technology may rapidly change the role played by margins. Later discussions will show how new technologies and management systems are reshaping the connections between producers and retail outlets. Not only will changing patterns of consumer purchasing reshape the nature of demand for services provided by retail trade, wholesale trade, and transportation, but the net productivity of these systems may change radically. Meeting demand for a series of niche markets expected to change quickly, for example, clearly requires a different retail and delivery network than a system designed to meet demand for a comparatively undifferentiated product competing entirely on the basis of price.[5]

Table 4-1 indicates the changes in margins that occurred between 1972 and 1984 for the amenity "Food." In 1972, for example, groceries (food purchased for off-premise consumption) required a commodity mix with more transportation & warehousing and food & kindred products, but less wholesale & retail trade than it did in 1984.[6]

The conversion from goods and services needed to satisfy an amenity to commodities results in a rearrangement of the consumption recipe into a consistent set of consumer demands to which industries can respond. Commonly referred to as final demand, this demand stimulates a second round of interindustry intermediate demand for various commodities needed as inputs in the production process. The inputs, which consist of physical materials, services, and the capital and labor required to produce output, are referred to here as the production recipe.

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[2] Office of the U.S. Trade Representative, "U.S. National Study on Trade in Services," Washington, DC, December 1983.

[3] James B. Quinn and Christopher E. Gagnon, "Will Services Follow Manufacturing into Decline?" *Harvard Business Review*, November/December 1986, p. 101.

[4] Based on the 1977 margins published in U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, vol. 64, No. 5, May 1984, p. 46.

[5] For the purposes of the analysis presented throughout this document, consumer purchases expressed in the categories of the "National Income and Product Accounts" of the U.S. Department of Commerce, Bureau of Economic Analysis (historic diskettes), are converted to demand expressed in input-output categories through use of a "bridge" provided by the U.S. Bureau of Economic Analysis ("The 1977 Input-Output Structure of the United States," *Survey of Current Business*, vol. 64, No. 5, May 1984, pp. 46-49). A similar bridge between government purchases and input-output categories was also made available by the Bureau of Economic Analysis.

[6] The 1984 commodity mix is based on the "1977 Input-Output Commodity Composition of Personal Consumer Expenditure," published in the *Survey of Current Business*, vol. 64, No. 5, May 1984.

Table 4-1.—The Commodity Mix for Food in 1972 and 1984[a] (current dollars, in percent)

	Food purchased for off-premise consumption		Purchased meals & beverages		Other consumer food purchases		Total	
Industry	1972	1984	1972	1984	1972	1984	1972	1984
Transportation & warehousing	3.6%	2.4%	0.0%	0.1%	0.9%	0.7%	2.6%	1.7%
Wholesale & retail trade	29.5	32.7	0.0	0.0	41.3	40.6	23.9	25.1
Finance & insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Livestock and livestock products	0.9	1.1	0.0	0.0	1.3	1.2	0.8	0.8
Other agricultural products	3.1	3.3	0.0	0.0	2.0	1.4	2.3	2.3
Food & kindred products	62.1	60.1	0.0	0.0	13.9	17.4	43.8	41.6
Tobacco manufacturers	0.0	0.0	0.0	0.0	40.6	38.7	3.6	3.1
Eating & drinking places	0.0	0.0	100.0	98.4	0.0	0.0	22.4	24.7
Amusements	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.4
Other	0.8	0.4	0.0	0.0	0.0	0.0	0.5	0.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total (billions of dollars)	**115**	**183**	**37**	**69**	**15**	**22**	**167**	**273**

How To Read This Table: On average, $100 in groceries purchased in 1984 ("food purchased for off-premise consumption") was allocated as follows: $2.40 went to transportation and warehousing businesses, $32.70 went to grocery stores and other wholesale and retail businesses, and $60.10 went to firms that supply food to the system. A significant fraction of the $60.10 *received* by these firms, of course, went to pay their suppliers. For an estimate of these "intermediate inputs," see table 4-2.

NOTES: Totals may not equal 100 percent due to rounding.

[a] The 1984 Commodity Mix is estimated using the 1977 composition updated with 1984 demand for these products.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "The Input-Output Structure of the U.S. Economy," *Survey of Current Business*, April 1979 for 1972 data, and May 1984 for 1977 data; "National Income and Product Accounts," *Survey of Current Business*, table 2.4, July 1987.

THE PRODUCTION RECIPE

The production recipes for 9 of the 10 sectors listed earlier are summarized in table 4-2 for the years 1972 and 1980. The table indicates that the 1980 recipe for making $100 of output in the Construction sector involved:

- total intermediate input purchases of $56.80: $1.20 in products from the Natural Resource industries, $0.10 from other Construction businesses, $7.30 from manufacturing enterprises paying low wages, $20.40 from Medium Wage Manufacturing businesses, etc.; and
- $43.20 in the form of wages paid and returns to capital in the Construction sector.

Table 4-2 exposes expected differences in the production recipes of different business categories. The value-added generated by manufacturing firms in 1980 accounted for between 29.6 and 36.5 percent of total manufacturing output, while intermediate purchases—those goods and services purchased from other businesses that become part of a final manufactured product—account for the rest. On the other hand, in the relatively labor-intensive fields of Transportation & Trade, Transactional Activities, and Personal Services, value-added accounts for 59.0 to 72.8 percent of total sectoral output.

Table 4-2 includes only direct intermediate purchases with expected lifetimes of less than a year. It does not include purchases of buildings or capital equipment needed to expand operations or replace old machinery.[7] But capital equipment is clearly an essential ingredient in any production recipe. The National Accounts refer to items that last more than a year as Gross Private Fixed Investment (GPFI). This category includes purchases of residential and nonresidential structures, and of capital equipment such as machine tools, computers, and tractors. Components of GPFI include accounts for items bought as both replacements for older equipment and equipment purchased for expansion.

Purchases of producers' durable equipment (PDE) are nearly half of the 1984 GPFI total.[8] The remainder consists primarily of non-residential and residential structures, which each represent about

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[7] A more detailed examination of the role of capital flows in a dynamic model of the economy has been developed. See W. Leontief and F. Duchin, "The Impacts of Automation on Employment, 1963-2000," Contract #PRA-8012844 to the National Science Foundation, Washington, DC, April 1984, p. 2.1.

[8] Unless otherwise noted, data about PDE comes from table 5.7, "Private Purchases of Producer's Durable Equipment by Type in Constant Dollars," in "National Income and Product Accounts," op. cit., footnote 5.

Table 4-2.—Recipes for the Production Sectors

Production sector	Natural Resources	Construction	Low Wage Manufacturing	Medium Wage Manufacturing	High Wage Manufacturing	Transport & Trade	Transactional Activities	Personal Services	Social Services
The 1980 Direct Requirements Table (1980 I-O in 1980 dollars, in percent)									
Natural Resources	27.2%	1.2%	4.4%	12.6%	20.4%	2.4%	1.2%	3.4%	2.6%
Construction	2.5	0.1	0.5	0.6	0.7	1.2	3.6	1.4	2.2
Low Wage Manufacturing	0.4	7.3	27.3	2.0	2.3	0.7	0.2	1.9	0.7
Medium Wage Manufacturing	3.9	20.4	2.8	18.6	5.9	5.1	1.6	5.0	2.6
High Wage Manufacturing	8.8	6.8	15.4	15.0	29.0	5.5	1.1	6.7	3.2
Transportation & Trade	4.1	10.5	7.5	8.6	7.7	8.8	2.0	7.1	2.5
Transactional Activities	5.7	9.9	4.6	5.2	3.7	12.6	15.6	10.1	5.9
Personal Services	0.5	0.5	0.6	0.7	0.5	2.2	1.1	4.8	0.8
Social Services	0.3	0.1	0.4	0.4	0.2	0.5	0.9	0.6	1.2
Total intermediate inputs	53.3	56.8	63.5	63.7	70.4	39.2	27.2	41.0	21.7
+									
Value-added	46.7	43.2	36.5	36.3	29.6	60.8	72.8	59.0	78.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
The 1972 Direct Requirements Table (1972 I-O in 1980 dollars, in percent)									
Natural Resources	26.1%	1.1%	6.0%	14.2%	18.2%	2.9%	1.4%	2.9%	2.5%
Construction	1.7	0.0	0.3	0.3	0.5	1.2	4.2	1.1	1.8
Low Wage Manufacturing	0.4	6.8	30.4	1.9	2.4	0.5	0.4	2.9	0.5
Medium Wage Manufacturing	3.0	19.3	3.7	16.7	6.2	5.5	1.6	4.7	1.5
High Wage Manufacturing	6.4	10.8	15.2	17.0	26.8	5.4	2.1	11.2	2.1
Transportation & Trade	2.4	8.9	6.9	6.5	5.4	6.9	2.2	4.5	1.7
Transactional Activities	4.8	5.2	4.4	4.9	3.5	10.2	16.1	10.1	4.4
Personal Services	0.3	0.4	0.7	0.8	0.5	2.1	1.6	4.6	0.6
Social Services	0.2	0.1	0.4	0.4	0.2	0.6	1.1	0.3	0.8
Total intermediate input	45.3	52.5	68.1	62.6	63.6	35.4	30.6	42.2	16.0
+									
Value-added	54.7	47.5	31.9	37.4	36.4	64.6	69.4	57.8	84.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

How To Read This Table: On average, each $100 in sales made by a Natural Resource business in 1980 resulted in $46.70 paid as compensation to employees in Natural Resource businesses or payments to the owners of these businesses, or indirect business taxes paid by these businesses, collectively called "value-added." The remainder of the $100 in sales went to pay firms that directly supplied Natural Resource industries. $2.50 went to purchase goods and services from construction firms, $0.40 went for purchases from Low Wage Manufacturing firms, $3.90 from Medium Wage Manufacturing, etc. These estimates reflect only the direct inputs, not the secondary or indirect contributions which are estimated in table 4-4.

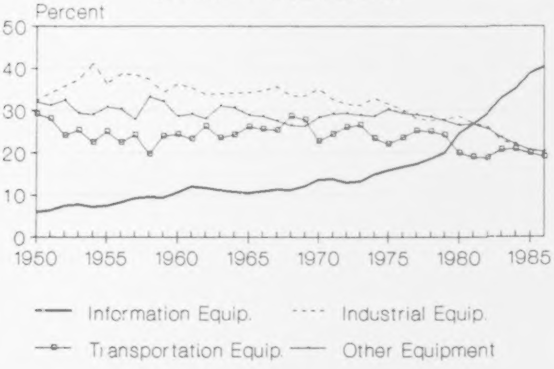
NOTE: Totals may not equal 100 percent due to rounding.

SOURCE: Office of Technology Assessment, from data provided by the U.S. Department of Commerce, Bureau of Economic Analysis, "The Input-Output Structure of the U.S. Economy," 1972, *Survey of Current Business*, April 1979 and Input-Output Tables, 1980, unpublished; U.S. Department of Labor, Bureau of Labor Statistics, "Time Series Data Base for Input-Output Industries," unpublished.

one-quarter of GPFI. Residential structures are not considered to be part of the production recipe and expenditures on non-residential structures have remained relatively constant, leaving PDE as the component of capital investment that has experienced the most change. Most of this change has been in the form of purchases of information processing equipment, which increased from 6 percent of PDE in 1950 to over 40 percent of all such investment in 1986, with most of the growth occurring since 1973 (see figure 4-1). Two-thirds of the increase was attributable to two categories of equipment: office, computing, & accounting machines; and communications equipment. Of the growth in office, computing, & accounting machines, 93 percent occurred during the last 10 years. Recent estimates attribute 77 percent of all of the office, computing, & accounting machines and 95 percent of the communication equipment expenditures to purchases made by the service sector.[9]

The other components of PDE—industrial, transportation, and other equipment—are of roughly equal size and all have lost about the same share of total expenditures, falling from about one-third in 1950 to about 22 percent in 1985.

Figure 4-1.-Share of Producers' Durable Equipment (constant 1982 dollars)



How To Read This Figure: Information equipment (computers, photocopiers, communication equipment, instruments, and related equipment) were only 6% of all business investment in producers' durable equipment in 1950, but were 40% in 1986. The percentages are computed after converting all spending to constant dollars. Producer durables were almost exactly half of all private investment in 1986, with the remaining investment going to buildings and other structures.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 5.7.

In standard accounts, GPFI is treated in the same manner as consumer purchases. Unless otherwise stated, however, the calculations presented in this analysis will treat *both* durable and non-durable elements of production as being part of the production recipe. Purchases of residential structures were examined in chapter 2 and are not included in the production recipe because they are not considered an input to production.

There are, of course, powerful links that cannot be exhibited in a table such as 4-2. The health of U.S. research and development efforts, for example, may be badly hurt if manufacturing capacity in an industry moves offshore, since there is evidence that commercially useful research thrives when it is integrally connected with practical manufacturing problems.[10] Likewise, every business relies on educated workers as an "input," but schools are not formally linked as an input in the production process. Such connections must be recognized using tools other than the ones presented here.

The table also reports all value-added as a single statistic, lumping labor costs of managers, production workers, and scientists together with the cost of capital. In fact, some of the most interesting changes in production recipes are occurring within these value-added categories. Chapter 10 will explore the value-added recipe in much greater detail.

As prices, technologies, regulations, and other factors change, so will the recipe used for production. Generally, the process of changing this recipe is slow and gradual; even a large shock such as the quadrupling of oil prices between 1972 and 1980 had a long lag period before an adjustment was incorporated into the production process.[11] Nevertheless, comparing the 1972 production recipes with those of 1980 reveals that in almost every sector, the level of inputs—particularly service sector products—increased between 1972 and 1980.

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[9] Stephen S. Roach, "The Information Economy Comes of Age," *Information Management Review*, vol. 1, No. 1, summer 1985.

[10] For a discussion of this link, see Stephen S. Cohen and John Zysman, "The Myth of a Post-Industrial Economy," *Technology Review*, February/March 1987; or Charles F. Sabel, et al., "How To Keep Mature Industries Innovative," *Technology Review*, April 1987.

[11] See Anne Carter, "Changes in Input-Output Structure Since 1972," *Interindustry Review*, Data Resources Inc., summer 1980, p. 1.16; and Stanley J. Feldman and Karen Palmer, "Structural Change in the United States: Changing Input-Output Coefficients," *Business Economics*, January 1985, p. 39.

Chapter 6 provides a detailed discussion of the ways production recipes are changing. Major changes can be found in virtually every business network. For example:

- Heating oil dealers have been able to cut down on the number of trucks and drivers, and on their inventories, by maintaining data on the capacity of customers' tanks, consumption rates, and the weather. The recipe has been changed, substituting information for vehicles, people, and storage facilities.
- Levi Strauss & Co. uses 3-D computer imaging equipment to simulate how different fabrics and styles will look and wear, instead of producing samples. Software and computers have replaced sewing machines and material.
- Advances in polymer technology and a desire to boost fuel efficiency have altered the recipe for producing a car, as high strength plastics and aluminum are substituted for iron and steel. Computer-Aided-Design and robotics have optimized designs so that less steel is used.
- Banks have used automated tellers and communication networks to substitute for many hand operations.

In all of these cases, changes in the recipe of production, whether as a result of price changes or technological innovation, have altered the respective positions of industries in the U.S. economy.[12]

Intermediate Inputs and Direct Linkages

As table 4-2 indicates, the manufacturing sectors make comparatively heavy use of intermediate inputs purchased from other businesses. Roughly two-thirds of the value of manufacturing sales must go to pay for intermediate inputs supplied by other sectors, while the three sectors retain significantly less than half of the sales price of their goods. In comparative terms, the Social Services sector is only weakly linked to other parts of the economy. Of the price of Social Services sold, 78.3 percent results in direct value-added (returns to capital and labor) to the Social Service industries themselves; not much "leaks out" to the other sectors of the economy. Indeed, this insular quality holds true for all the sectors that are characterized as services.

Taken as a whole, the economy became more interconnected between 1972 and 1980, as the share of goods and services produced for use as intermediate inputs rose by 1.2 percent. This translates into more than $60 billion (1980 dollars) if applied to the 1980 economy, or more than all the value-added generated by the eating & drinking industry in that year.[13]

Some sectors became much more highly linked during the 1972-1980 period. The Natural Resource and High Wage Manufacturing sectors made much heavier use of intermediate inputs, increasing their intermediate inputs by 8 and 7 percentage points, respectively. The bulk of the increase for both of these sectors occurred between 1972 and 1977, and was in the form of energy-related commodities: crude & refined petroleum, chemicals, and electric, gas, and water services (utilities). Nevertheless, the single biggest increase in an input for the High Wage Manufacturing sector was the service provided by the wholesale & retail trade industry.

The change in use of intermediate inputs is not uniform. For example, the Natural Resource sector greatly reduced inputs of livestock and agricultural products inputs while High Wage Manufacturing reduced its purchases of iron ore, steel products, and metal containers.

Transactional Activities and Low Wage Manufacturing actually reduced their intermediate inputs between 1972 and 1980, becoming less tightly linked to the rest of the economy. In the case of Low Wage Manufacturing, the bulk of the decrease was attributable to a decline in textile and apparel inputs; for Transactional Activities, the decrease was more evenly spread between paper products, real estate, and maintenance & repair construction.

In many cases, relatively small total changes mask significant offsetting changes in production recipes.

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[12] Since many of the sectors reflect the combination of many industrial processes, changes in demand, which necessarily change the share of a particular product or industry within the broader sector, may appear to be a change in recipe at this higher level of aggregation.

[13] This is 0.012 times $5,210 billion (total gross output in 1980 in 1980 dollars).

For example, intermediate inputs for Construction grew only 4 percentage points. Construction, however, greatly increased its purchases of business service inputs while reducing demand for refined petroleum. The Transportation & Trade sector also increased its use of business services, as well as communication services. Overall, Medium Wage Manufacturing increased its use of inputs only slightly, but its inputs of wholesale & retail trade, electronic components, and office & computer equipment increased dramatically, while its use of primary iron & steel, livestock products, and food & kindred products decreased.

When these sectors are combined and their relative size is taken into account, it becomes clear that the Nation's production recipe has undergone a significant realignment, using more service inputs and fewer raw or semi-finished materials.[14] Table 4-3 lists the 10 industries which contributed most to an increase in intermediate inputs and the 10 that contributed most to declines between 1972 and 1980.

Table 4-3.—Changes in Production Recipe Inputs From 1972 to 1980 (ranked by greatest gain and loss)

Industries gaining share	Industries losing share
1. Wholesale & retail trade	Primary iron & steel manufacturing
2. Business services	Livestock & livestock products
3. Communications	Other agricultural products
4. Electronic components & accessories	Primary nonferrous metals manufacturing
5. Maintenance & repair construction	Motor vehicles & equipment
6. Electric, gas, water, & sanitary services	Stone & clay products
7. Transportation & warehousing	Forestry & fishery products
8. Plastic & synthetic materials	Paper & allied products
9. Office, computing, & accounting machines	Lumber & wood products
10. Finance & insurance	Broad & narrow fabrics

How To Read This Table: Intermediate inputs from wholesale and retail trade were responsible for the largest share of the total increase in intermediate inputs occurring between 1972 and 1980. Changes in intermediate inputs of primary iron & steel manufacturing contributed most to counteract this increase.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "The Input-Output Structure of the U.S. Economy," 1972, *Survey of Current Business*, April 1979 and Input-Output Tables, 1980, unpublished; converted to a constant dollar basis using Bureau of Labor Statistics Output Deflators, unpublished; U.S. Department of Labor, Bureau of Labor Statistics, "Time Series Data Base for Input-Output Industries," unpublished.

The overall increase in the use of intermediate inputs and the pronounced rise of service sector inputs suggests that the economy has become more specialized.[15] This specialization is apparent in the fact that more interindustry transactions are taking place, requiring significant increases in wholesale & retail trade inputs as well as inputs that tend to facilitate transactions: communications and business services.

Much of this specialization is fueled by technological developments and competitive pressures that make it nearly impossible, both technically and financially, for any one firm to conduct all facets of production. Specialized contractors fill this void, providing the contracting firm with additional flexibility because costs are shared, but also making the firm more dependent because of the strategic position of the contractor in the production process. Chrysler cites a 50-percent decrease in engineering costs to its increased use of suppliers.[16]

Much of the increase in interindustry connections is also due to new technologies, particularly information processing technologies, that allow coordination of complex production processes which increasingly span the globe. As a result of this growth in subcontracting, and the wider geographical dispersion it entails, service sector businesses have thrived because of the increased need for legal contracts, consulting services, transportation, communication, and wholesale & retail trade.[17]

Indirect Linkages

Although the analysis of direct input requirements shows how recipes have changed, it does not include the indirect economic activity generated by an industry's output. As in the frozen pizza example, grain is needed to make flour, fertilizer is used to produce grain, chemicals are needed to make fertilizers, and so on. Numerous "upstream" and "downstream" linkages are associated with almost every commodity, although some are more tightly linked than others. By tracking these connections, the impact of buying a new domesticly produced car on the auto industry's suppliers (like the steel industry) becomes apparent, as does the secondary impact of those increased steel purchases on the steel industry's suppliers (like coal). The indirect connections between different parts of the economy, implicit in table 4-2, can be illustrated using mathematical techniques described in the appendix to estimate how $1 of output in one industry sector generates value-added in other sectors, incorporating both direct and indirect effects.

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[14] See Andrew G. Clem and William P. Thomas, "New Weight Structure Being Used in Producer Price Index," *Monthly Labor Review*, August 1987, pp. 12-21 for a similar analysis.

[15] See Anne Carter, *Structural Change in the American Economy* (Cambridge, MA: Harvard University Press, 1970), for a more detailed analysis of specialization.

[16] Elizabeth A. Haas, "Breakthrough Manufacturing," *Harvard Business Review*, March/April 1987, p. 79.

[17] Charles F. Sabel, et al., op. cit., footnote 10, p. 32; and Richard McKenzie, "The Emergence of a Service Economy: Fact or Artifact?" Policy Analysis No. 93, Cato Institute, Washington, DC, October 1987.

Table 4-4 reconfirms that the Social Services sector is the most "insular," even when indirect effects are taken into consideration. Of the total value-added generated throughout the U.S. economy by demand for Social Services, 77 percent is retained within the Social Service sector—only 23 percent spills over into the rest of the economy (e.g., for purchase of hospital or school supplies).

As was the case when only direct effects were examined, this insular quality holds true for all the sectors characterized as services when indirect effects are included. On average, almost two-thirds of the value-added generated from demand for services stays in the service sectors. Their linkage to other sectors is relatively weak; of every $1 of value-added generated by demand for services, only around 15 cents ends up in manufacturing. The biggest spillover to manufacturing, more than 16 cents on each dollar, comes from demand for Personal Services; the smallest, 8 cents, comes from demand for Social Services.

A very different situation prevails in manufacturing, where the three sectors—as before—reap under half of the value-added generated from the sale of their goods, passing the other half on to other sectors of the economy. Low Wage Manufacturing is the most insular of the three, but even in this case, nearly one-quarter of every dollar spent on goods produced by the Low Wage sector, such as apparel, ends up in the coffers of a service industry—especially Transportation & Trade (12 cents per dollar) and Transactional Activities (9 cents).

This strong link to services is also evident in the Medium Wage sector; about one-quarter of the value-added generated by demand for the products of Medium Wage Manufacturing is captured by services. But in contrast to the Low Wage sector, the demand for $1 of Medium Wage products, such as electronics or processed food, also translates into 12 cents of value-added for the Natural Resource sector. The other major link to Natural Resource industries—other than the Natural Resource sector itself—is High Wage Manufacturing. Only about 43 cents of every dollar of value-added resulting from demand for High Wage manufactured goods is retained by the High Wage sector. The bulk of the remaining 57 cents is divided between Natural Resources, reaping 17 cents, and Medium Wage Manufacturing, Transportation & Trade, and Transactional Activities, each gaining more than 8 cents worth of value-added.

The Natural Resource and Construction sectors are the least insular of all. Only 36 cents of $1 in value-added generated by demand for Construction goes to construction firms, while five of the eight other sectors gain at least a nickel in value-added from such purchases. About one-quarter of the value-added that is not retained by Construction from demand for its own products is split between Transportation & Trade and Transactional Activities—14 and 12 cents, respectively. The Natural Resource sector is the least insular sector, reaping only 25 cents of the dollar of value-added that results from purchases of Natural Resources. Major beneficiaries from demand for this sector's products are Transportation & Trade (16 cents) and Transactional Activities (11 cents).

Table 4-5 provides a summary view of the way that each of the sectors is linked to the rest of the economy. The table estimates the total industry output resulting from $1 of demand in each of the 10 sectors. This statistic is conventionally called the "output multiplier."[18]

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[18] One dollar of sales can, by definition, generate only $1 of value-added. If an industry purchases no items from other industries, there would be no direct or indirect links to the rest of the economy, and $1 of its output would generate only $1 of total output (namely its own). All value-added would be captured by the producing enterprise. If a large portion of the value in an industry's sales represents the cost of goods and services purchased from other enterprises, only a fraction of the total value-added in the economy generated by the value of its sales will remain in the industry itself. The total output generated by $1 of the industry's output will be larger than 1.0 because the intermediate outputs are counted at least twice (once as a part of the output of the industry itself, and once as the output of the supplying industries). A chain of connections thus leads to multiple counting when an industry is not completely insular. The extent of this multiple counting provides a good measure of the degree to which the industry is linked

Table 4-4.—Sectoral Linkages: Value-Added Derived by Production Sector From the Purchase of $100 of a Sector's Product[a]

(1980 dollars, in percent)

Production sector	Natural Resources	Construction	Low Wage Manufacturing	Medium Wage Manufacturing	High Wage Manufacturing	Transport & Trade	Transactional Activities	Personal Services	Social Services
Natural Resources	25.3%	6.1%	6.8%	11.8%	16.9%	5.6%	3.6%	4.9%	2.5%
Construction	10.5	35.9	3.3	3.9	4.3	3.8	12.7	3.9	2.7
Low Wage Manufacturing	2.3	4.7	47.6	2.4	2.7	1.6	2.1	2.5	1.0
Medium Wage Manufacturing	13.2	14.8	7.7	44.5	12.2	6.9	8.9	7.4	4.2
High Wage Manufacturing	12.9	10.5	11.8	12.4	43.4	5.7	5.3	6.5	3.0
Transportation & Trade	15.9	13.8	11.6	13.2	10.3	62.1	7.4	8.8	3.8
Transactional Activities	11.4	12.2	8.8	9.4	8.2	11.0	57.5	9.7	5.3
Personal Services	1.3	1.1	1.1	1.3	1.0	1.7	1.0	55.0	0.7
Social Services	7.1	0.9	1.2	1.2	0.9	1.6	1.4	1.3	76.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

How To Read This Table: Following all the direct and indirect effects, $100 of products purchased from Natural Resource businesses in 1980 created $25.30 in value-added in the Natural Resource businesses themselves, $10.50 in value added for the Construction industry, etc. The $100 purchase can only generate $100 in value-added throughout the economy. It can, however, create much more than $100 in *output*. Table 4-2 looked at direct effects of $100 in *output* produced by the Natural Resource industries. Table 4-4 looks at the chain of events created by $100 in *final demand for commodities produced* by Natural Resource industries.

[a] Based on the distribution of demand as it existed in 1984, includes 1977 capital flows table updated to 1984 levels.

NOTE: Totals may not equal 100 percent due to rounding.

SOURCE: Office of Technology Assessment, from data provided by the U.S. Department of Commerce, Input-Output Tables, 1980, unpublished, Bureau of Labor Statistics, "Time Series Data Base for Input-Output Industries," unpublished, and 1977 Capital Flows Table.

Table 4-5.—Changing Sectoral Linkage: Output Multipliers for 1972 and 1980 (includes capital equipment)

Production sector	1972	1980
High Wage Manufacturing	2.6	3.0
Natural Resources	2.3	2.8
Low Wage Manufacturing	2.9	2.8
Medium Wage Manufacturing	2.6	2.8
Construction	2.5	2.6
Transportation & Trade	2.0	2.1
Personal Services	2.3	2.1
Transactional Activities	1.8	1.7
Social Services	1.5	1.6
Total	2.3	2.4

How To Read This Table: In 1972, $100 in *final demand for commodities produced* by Natural Resource industries created $260 in total output throughout the economy. This had risen to $300 in 1980 because the sector had become more highly linked with the rest of the economy. A completely insular business purchasing nothing from the outside would create $100 in output and $100 in value-added for $100 in sales. A highly linked business might buy a $90 product from suppliers and sell it for $100. This creates at least $190 in total output for the economy. Adding output inherently involves double-counting because each output contains the value of intermediate inputs.

SOURCE: Office of Technology Assessment, from data provided by the U.S. Department of Commerce, Bureau of Economic Analysis, "The Input-Output Structure of the U.S. Economy," 1972, *Survey of Current Business*, April 1979 and Input-Output Tables, 1980, unpublished; U.S. Department of Labor, Bureau of Labor Statistics, "Time Series Data Base for Input-Output Industries," unpublished, 1972 and 1977 Capital Flows Table.

It is again evident that service enterprises are comparatively independent of the rest of the economy, while the Natural Resource and manufacturing sectors are highly linked. The changes in output multipliers between 1972 and 1980 tend to parallel the changes in production recipe: Natural Resources and High Wage Manufacturing had the largest increases, while Low Wage Manufacturing, Transactional Activities, and Personal Services experienced a decrease. In other words, Transactional Activities has altered its operations so that this sector had less interaction with other sectors in 1980 than in 1972.

Presumably, industries becoming more tightly linked with the rest of the economy require more connections to other business or more expensive inputs. They may also be contracting for work or buying inputs that were previously generated "in-house."[19] The analysis of High Wage Manufacturing's production recipe indicates that the bulk of these additional links are with trade- and energy-intensive sectors, suggesting that the increase in connectivity is due to the higher cost of energy and the increased number of transactions needed for production—possibly due to the use of imported inputs.[20]

Table 4-5 also shows that the output multiplier for the whole economy increased between 1972 and 1980. The U.S. economy has become more interconnected in spite of the fact that sharp growth has been experienced in service sectors, which exhibit comparatively weak links to the rest of the economy. These seemingly contradictory findings are explained by the fact that businesses are increasingly using services as an input into their production recipes, both directly and indirectly—thus increasing services' role in the economy and creating a higher level of interindustry linkage.

Increased linkages have both attractive and unattractive effects. A more tightly linked economy allows a greater degree of specialization, flexibility, and efficiency. Nevertheless, interdependent sectors also mean that an economic downturn in one sector will quickly spread to other sectors of the economy. Unlike the situation in manufacturing, where growth in demand for its products has also meant growth in the Natural Resource and service sectors, the growth of services—especially that of Transactional Activities—results in little growth outside transactional businesses. On the other hand, the health of transactional service businesses may depend heavily on a healthy manufacturing sector.[21]

The concept of linkage takes on greater importance when viewed in terms of international trade, an issue that will be addressed in chapter 8. Trade has a major effect on manufacturing, which is highly linked to the rest of the economy. Therefore, trade problems in manufacturing ripple throughout the U.S. economy.

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continued from previous page
directly and indirectly to other enterprises. See J.M. Szyrmer, "Measuring Connectedness of Input-Output Models: Survey of Measures," *Environment and Planning*, vol. 17, 1985, pp. 1591-1612, for a discussion of the use of this measure.

[19] See John Tschetter, "Producer Services Industries: Why Are They Growing So Rapidly?" U.S. Bureau of Labor Statistics, *Monthly Labor Review*, December 1987, pp. 31-41.

[20] For example, the "big three" U.S. auto companies now draw a significant amount of their parts from foreign producers. See Kevin Flaherty, "Foreign Sourcing by the U.S. Automobile Industry," U.S. Congressional Research Service, Nov. 8, 1985.

[21] Stephen S. Cohen and John Zysman, "The Myth of a Post-Industrial Economy," op. cit., footnote 10.

NETWORKS THAT PROVIDE AMENITIES

The methods just described can be used to show how the set of consumer and government purchases needed to satisfy specific amenities described in Part I connect to direct and indirect demand for industry output. The chain of analysis proceeds as follows:

1. consumers purchase a variety of goods and services to achieve an amenity,
2. these purchases translate into direct demand for output from a variety of different industries (including businesses providing "margins" such as transportation, insurance, and trade), and
3. the value of the products and services sold to consumers is distributed across a complex network of businesses because of direct and indirect connections.

It is possible, therefore, to connect purchases for an amenity such as Food with economic activity distributed throughout the U.S. economy. The distribution of value-added generated in each industry by purchases needed to serve 11 major amenity groups are summarized in table 4-6 for 1984 and 1972. This table shows how all value-added flowed through the economy from producing sectors to amenity categories in each of the 2 years. The sum of all value-added in each year is the entire U.S. gross national product.

Table 4-6 indicates, for example, that including all direct and indirect effects, approximately 15 percent of the U.S. Food bill goes to purchase value-added from farms and other Natural Resource operations—down from 17.6 percent in 1972. Similar decreases in share came from the Medium Wage and High Wage Manufacturing sectors. The bulk of the value-added required for the Food amenity, increasingly true since 1972, comes from the Transportation & Trade sector.

Although Natural Resource inputs were above average for the Housing, Transportation, and Export amenities both in 1972 and 1984, the share of value-added contributed by the Natural Resource sector has declined in 9 of the 11 amenities since 1972.

Interestingly, the largest share of value-added required for Housing, both in 1972 and 1984, does not go to the Construction sector. Rather, Transactional Activities accounts for nearly 45 percent, due to the enormous impact of the real estate industry on homebuying.[22] This is up dramatically from 1972. Exports also require a larger share of inputs from the Transactional sector as does Personal Business and Communication. Between 1972 and 1984, the increased spending for Personal Business and Communication translated directly into value-added for Transactional Activities, while every other production sector lost share—particularly Construction and High Wage Manufacturing. Indeed, the importance of Transactional Activities has increased sharply since 1972 for every amenity except Defense, which is sensitive to the choice of 1972 as an endpoint due to the influence of the Viet Nam War.

Not surprisingly, value-added from the Social Service sector plays a large role in creating the Health, Education, Government, and Defense amenities, and this role has increased in size compared to 1972. All amenity groups except Defense and Personal Business and Communication registered increased demand for inputs from Transportation & Trade.

The Food, Transportation, Clothing and Personal Care, Recreation and Leisure, Federal Defense, and Export amenities make the heaviest use of manufactured inputs. With the exception of Defense, however, the share of value-added contributed by manufacturing declined significantly between 1972 and 1984. Purchases from High Wage Manufacturing fell sharply, especially for Transportation, Clothing and Personal Care, and Exports.

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[22] The National Income and Product Accounts also impute a rental-equivalence value for homeowners, which is allocated to the real estate industry.

Table 4-6—Networks That Provide Amenity: Contributions From Sectors Needed To Satisfy Amenity categories, 1984 and 1972 (1980 dollars, in percent)

Production sectors	Amenity categories Food	Housing	Transportation	Health	Clothing and Personal Care	Education	Personal Business and Communication	Recreation & Leisure	Government n.e.c.	Federal Defense	Exports	Total
1984[a]												
Natural Resources	15.0%	9.7%	14.5%	4.3%	4.9%	4.0%	2.6%	6.0%	5.2%	4.4%	16.4%	9.1%
Construction	3.3	12.9	6.1	3.7	2.4	5.2	2.8	3.7	11.0	3.8	3.4	6.2
Low Wage Manufacturing	1.5	3.2	2.7	1.5	17.0	1.2	1.1	3.5	1.9	1.4	3.8	3.2
Medium Wage Manufacturing	16.8	6.8	7.8	6.6	5.2	4.8	6.7	12.1	6.1	10.9	19.4	9.7
High Wage Manufacturing	8.1	5.7	16.1	5.9	7.6	3.3	2.9	7.1	5.0	17.6	19.5	8.7
Transportation & Trade	39.1	12.8	30.1	10.3	39.1	4.1	6.0	21.7	8.0	8.1	18.8	19.3
Transactional Activities	12.7	44.7	12.3	15.6	12.8	7.0	70.9	15.4	12.4	9.0	16.1	23.5
Personal Services	1.6	2.3	8.0	1.4	10.0	0.6	3.2	14.4	1.4	1.2	1.5	3.7
Social Services	1.8	2.0	2.3	50.8	1.1	69.9	3.7	16.2	49.1	43.4	1.1	16.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total (billions of 1980$)	428	672	264	285	171	180	161	200	120	173	238	2,892
1972[b]												
Natural Resources	17.6%	13.8%	13.1%	5.2%	5.7%	6.1%	3.7%	6.7%	7.4%	20.1%	15.9%	12.5%
Construction	3.7	12.2	7.1	5.6	4.1	6.1	5.1	5.5	12.8	9.8	3.9	7.6
Low Wage Manufacturing	1.5	3.8	2.9	1.7	18.3	1.3	1.6	4.1	2.0	3.5	4.1	3.8
Medium Wage Manufacturing	19.8	7.0	8.0	6.3	5.5	4.8	8.1	12.3	6.6	10.2	17.2	10.0
High Wage Manufacturing	10.7	8.4	22.7	8.0	11.3	5.1	5.4	9.6	8.0	14.6	27.9	12.0
Transportation & Trade	34.4	12.1	27.0	10.1	33.9	3.8	6.7	21.2	7.3	14.4	17.0	18.3
Transactional Activities	9.6	37.8	10.2	13.9	10.3	5.7	61.6	11.7	11.0	11.7	11.6	18.1
Personal Services	1.2	2.9	6.3	1.2	9.8	0.5	4.0	12.4	1.3	2.0	1.3	3.5
Social Services	1.5	2.1	2.6	48.1	1.1	66.5	3.8	16.3	43.6	13.8	1.1	14.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total (billions of 1980$)	374	509	263	191	161	168	104	160	126	377	131	2,564

[a] Using 1984 demand and 1980 production recipe with adjustments made to the 1980 I/C for capital flows.

[b] Using 1972 demand and production recipe with adjustments made to the 1972 I/O for capital flows.

NOTE: Totals may not equal 100 percent due to rounding.

SOURCES: Derived from U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, for 1984 personal consumption expenditures (PCE) and government purchases, with adjustments made to the 1972 Input-Output Tables, *Survey of Current Business*, April 1979, 1980 Input-Output Table, unpublished, 1972 and 1977 Capital Flows Table; and U.S. Department of Labor, Bureau of Labor Statistics, 1984 trade estimates rebased into 1980 dollars, unpublished and Time Series Data Base for Input-Output Industries.

A CONCLUDING NOTE

This chapter provides a set of tools for viewing the economy as a series of interconnected networks, where the product of one sector works in conjunction with the products of another sector to satisfy the needs of a consumer—whether that consumer is a person, a business, or a government agency.

These tools can be used to explore many of the structural changes that have occurred in the past few years, and are the basis for speculating about future changes. This will be the task of chapter 5. The tools also provide a way of describing the operation of complex networks of business activities that must combine operations to deliver goods and services that consumers require for different amenities. This will be the task of chapter 6.

Chapter 5

Three Perspectives on Structural Change

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Chapter 5

Three Perspectives on Structural Change

Structural changes in the U.S. economy fall into three major categories:

1. changes in the contribution that each major business sector makes to the total value added in the economy, or the gross national product (GNP);
2. changes in the organization of firms measured in terms of their scale of operation and scope of production; and
3. and changes in the location of production.

Changes in these three areas have been underway for some time. Structural change is a dynamic process which reflects the interaction of many forces—primarily new technologies, shifts in consumer demand, the way producers satisfy that demand, increasing competition in international trade, and the introduction of new rules and regulations that govern business enterprises. The discussion that follows attempts to isolate the effects of these principle forces.

Understanding changes in the structure of the U.S. economy is critical for understanding changes in job generation, pay, and regional growth, and for estimating the likely direction of the economy in the future. The dynamics of an economy heavily dependent on natural resources are likely to be very different from one primarily dependent on intellectual resources. An economy consisting of tightly integrated networks of small establishments will behave differently in response to shifting domestic and international markets than one characterized by large, centralized establishments and firms. An economic structure that spreads wealth unevenly around the country, or that places the burden of structural adjustment primarily on a few regions, presents a unique set of problems. In all three cases, policies designed to facilitate growth and mitigate the pain of structural change depend on a clear grasp of the patterns of change and the forces shaping them.

SECTORAL CONTRIBUTIONS TO GNP

Structural change is measured first by the relative contribution each major business sector makes to GNP.[1] Since the 1950s, Natural Resource industries, Construction, and manufacturing (particularly High Wage Manufacturing), have contributed less to GNP, while Transportation & Trade and Transactional Activities have increased their relative contributions. Taken as a whole, the share of service businesses increased from 52 percent of GNP in 1950 to 63 percent in 1984; at the same time, the share of goods—defined as all manufacturing, Natural Resources, and Construction—fell from 48 to 37 percent. The rising share of the service sectors has been due to the strong growth in demand for services and, in the case of Transactional Activities (the fastest growing sector), a sharp increase in the use of this sector's products as inputs in the production recipe.[2] The opposite holds true for the manufacturing sectors, where demand has risen relatively slowly and production recipes have called for reduced use of manufactured products. Trade has tended to reinforce these trends.

Many of these patterns have been underway for some time. There has been considerable debate over whether the U.S. economy is "deindustrializing" and how such a phenomenon would be defined and measured.[3] Some evidence suggests that rates of decline in some manufacturing industries have accelerated since 1972,[4] and that some of this accelerated structural change can be attributed to slower economic growth.[5] Whether or not rates of change have increased, there is little doubt that the cumulative effect of change over the past two decades has been the creation of an economy where the origins of value are different—in some cases dramatically different—than they were two decades earlier. In the midst of such a process it is difficult to point to a particular moment when a sudden change in structure took place; such things are easier to see in retrospect.

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[1] Unless otherwise noted, all measurements of sectoral share are in constant 1980 dollars.

[2] For a discussion of the impact of technology and the growing complexity of production in the increased use of services, see James B. Quinn and Christopher E. Gagnon, "Will Services Follow Manufacturing Into Decline?" *Harvard Business Review*, November-December 1986; for a description of the role of tastes, incomes, and economic growth in promoting the growth of the service sector, see Robert Lawrence, *Can America Compete?* (Washington, DC: The Brookings Institution, 1984).

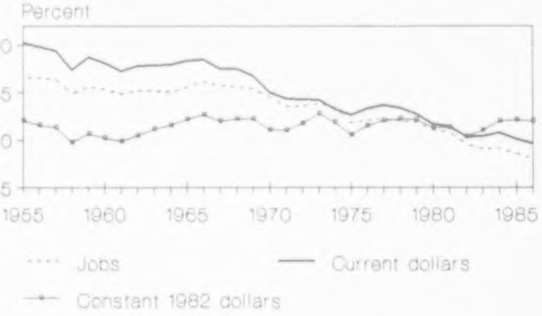
Any attempt to measure changes in the origin of value by business type faces two major dilemmas. First, how should a sector's share be measured—in "constant" dollars—a proxy for share of physical output—or in "current" dollars—the amount of money in which the economic activity actually occurred? Second, do the sectors selected for analysis accurately measure changes in the underlying structure of production, or is change masked by the categories chosen?

Constant and Current Dollars

The distinction between the type of measure used is critical, since measurement in constant dollars indicates that manufacturing's share of value-added has remained relatively constant for many years while this sector's current dollar share has fallen sharply (see figure 5-1). Both current and constant dollar measures provide useful views of the changes underway. The difference is largely due to productivity increases, which allow the same amount of goods and services to be produced for a relatively lower price (see box 5-A).

Measurement of output in current dollars, or the dollars of the day, has strong intuitive appeal, since

Figure 5-1.-Manufacturing's Share of GNP and Jobs (current and constant 1982 dolla^rs and persons)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 6.1, 6.2, and 6.10.

Box 5-A.—Productivity and Constant Dollars

Imagine an island that produced only pizzas and poems and sold equal numbers of both. Suppose that in 1950, 2 minutes of work were needed to produce either a pizza or a poem and that each cost $2. Suppose that thanks to surging innovation in pizza production, by 1980 poems still took 2 minutes of work and cost $2 dollars but pizza required only 1 minute and sold for $1 because prices were set in highly competitive markets.

If demand did not change with price, and if the capital investments needed to increase pizza productivity were negligible, the constant dollar percentage of production in the island would remain the same at 50-50, but the current dollar share of poetry would increase from one-half to two-thirds of the island's GNP.

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[3] The decline in the current dollar share of manufacturing has led to a controversy over whether the United States is deindustrializing. Bennett Harrison of the Massachusetts Institute of Technology and Barry Bluestone of Boston College, who popularized the term "deindustrialization," argue that the manufacturing sectors in the United States are in decline; see *The Deindustrialization of America* (Boston, MA: Basic Books, 1982). Charles Schultze and Robert Lawrence of The Brookings Institution argue that deindustrialization has not occurred (see Robert Lawrence, op. cit., footnote 2, and also Robert Lawrence, "The Myth of Deindustrialization," *Challenge*, November/December 1983). For a review of the subject, see R.D. Norton, "Industrial Policy and American Renewal," *Journal of Economic Literature*, vol. XXIV, March 1986, pp. 1-40.

[4] For an analysis which supports this conclusion, see Nicholas S. Perna, "The Shift from Manufacturing to Services: A Concerned View," *New England Economic Review*, January/February 1987; for an opposing view, see U.S. Department of Commerce, Office of Economic Affairs, "Changes in the Structure of the U.S. Economy Since 1960: A Primer," working paper, Washington, DC, January 1986.

[5] James H. Crossing and Arye L. Hillman, "Shifting Comparative Advantage and Senescent Industry Collapse," *The American Economic Review*, June 1986, p. 516; and Ronald E. Kutscher and Valerie A. Personick, "Deindustrialization and the Shift to Services," *Monthly Labor Review*, vol. 109, No. 6, June 1986, p. 10.

it uses the prices at which transactions take place.[6] Measured in current dollars, manufacturing's share of GNP fell from one-third in 1950 to less than one-quarter in 1984. The constant dollar measure reflected in the U.S. Department of Commerce's "Gross National Product by Industry" data series, however, reveals no discernible trend—indeed, it indicates a relatively stable share at about 22 percent of total output.[7] Manufacturing's share of GNP measured in current dollars has fallen largely because productivity increases in this sector have been passed on to consumers in the form of comparatively lower prices and demand has not risen enough to offset the price decline. Because increases in productivity frequently result in lower labor requirements, the current dollar measure tends to track employment in an industry (again see figure 5-1), making this a useful tool in analyzing policy considerations focusing on labor.

Constant dollar measures attempt to remove changes attributable to prices, by tracking actual changes in quantities. In theory, this measure provides a more accurate indication of contributions to GNP and thus structural change.[8] In practice, the process hinges on the arcane business of creating "deflators," which convert current dollars to the dollars of a particular year—constant dollars. This task has become increasingly difficult as the economy generates more value in specialized high-technology products and in services. It is particularly difficult during periods of high inflation like the late 1970s.

Accurate conversion from current to constant dollars is only possible where indexes can be based on measurable, fungible commodities like steel and oil.[9] But the bulk of GNP is composed of goods and services whose various characteristics and specifications do not stay constant over time, making direct comparisons without some type of quality adjustment inappropriate. The question of adjusting for quality becomes extraordinarily complex when diverse products are entering the market and many products are new. Is a computer purchased in 1988 so radically different from one bought in 1960 that it is effectively a different product? This problem is magnified in the case of services, which are in many cases even harder to quantify. Heart surgery might be more expensive today than it was 10 years ago, but the probability of surviving may be much higher.

Even in places where it is possible to develop a good estimate of the constant dollar value of an industry's product (e.g., a deflator for automobiles), developing a deflator for the *value-added* portion of that product proves to be difficult. Since value-added is primarily composed of compensation paid to workers and income retained by the business, there is no clear and intuitive interpretation for a value-added deflator. A discussion of various techniques used to deflate value-added appears in box 5-B. Given the limitations outlined in the box, it is clear that constant dollar value-added estimates should be interpreted with care.

Selecting the Categories for Measuring Sectoral Share

Chapter 4 pointed to the difficulty of selecting business sectors in a way that revealed rather than obscured the structural shifts underway in the U.S. economy. This problem haunts all attempts to express structural change in a limited number of categories. Observed shifts of economic activity from one sector to another can merely be an artifact of the measurement process, and not a true change. Spurious change can occur because different business types are combined in a single category, definitions have changed, or the measurement process has improved. This problem applies not just to the 9 business categories used here to summarize structural change; it can also apply to the 85 industries that were combined to make the 9.[10] For example, the

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[6] For a description of structural change using a current dollar measure, see U.S. Congressional Budget Office, *The Industrial Policy Debate*, Washington, DC, December 1983, p. 11; and Nicholas S. Perna, op. cit., footnote 4.

[7] Analysts using different data series and methodologies, including the one presented later in this section, find results which conflict with the finding that the manufacturing sector retains a stable share of GNP when measured in constant dollars. See Larry Mishel, "Trends in Manufacturing's Level and Share of Output," Economic Policy Institute, Washington, DC, November 1987, unpublished.

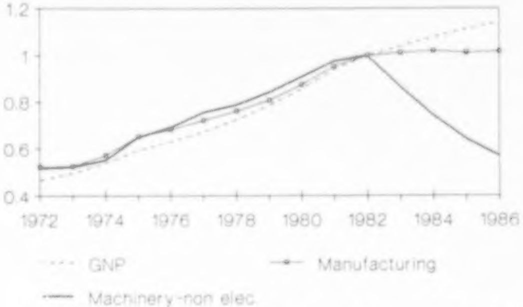
[8] For a more detailed examination of how to define and measure structural change, the strengths and weaknesses of constant versus current measurement, and what role employment measures can or cannot play, see "Changes in the Structure of the U.S. Economy Since 1960: A Primer," op. cit., footnote 4, or Nicholas S. Perna, op. cit., footnote 4.

[9] See A.G. Clem and W.D. Thomas, "New Weight Structure Being Used in Producer Price Index," *Monthly Labor Review*, vol. 110, No. 8, August 1987, pp. 12-21, for a description of how a new price basis is established.

[10] More than 500 sectors appear in the U.S. Department of Commerce's input/output tables available for the benchmark years. Unfortunately, the most recent year for which data at this level exists is 1977.

Box 5-B.—Deflating Value-Added

Figure 5-B.-Price Deflators for Various Sectors (1982=1.0)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 6.1 and 6.2.

Under ideal circumstances, deflators for value-added inputs are calculated using input-output techniques. The inputs purchased by each business are deflated separately and the total is subtracted from a deflated level of industry sales (total output), creating a residual which is deflated value-added. This technique, called "double-deflation," is recognized as a preferred method by the Commerce Department because of its use of a consistent set of price indexes. However, double deflation is only used on the 29 percent of the 1986 GNP generated by the manufacturing, farm, and construction sectors; a variety of scaling techniques and other methods are used for the rest of the economy.[1] But even the preferred method is subject to severe problems which limit its usefulness. Errors in the construction of the deflators or the calculation of the inputs or outputs appear in the remainder, which is value-added.

The problems encountered in creating a constant dollar value-added series, even in manufacturing, are made obvious by figure 5-B, where data are particularly good. The figure shows the deflator for the nonelectrical machinery industry (an industry category that includes computers), the deflator series for all manufacturing industries, and the deflator for GNP. It is apparent that a new deflator for computers was introduced in 1982.[2] Without this change, manufacturing deflators would have increased between 1982 and 1986. With the change, there was no significant difference. Changes in constant dollar manufacturing output for manufacturing are, therefore, partly an artifact of deflation techniques—not real structural change in the economy.

The rise of imports as intermediary inputs in the production process presents another problem, since most deflation techniques use domestically based deflators.[3] For example, suppose that General Motors buys its steel for autos from South Korea in both 1972 and 1980. If the price of imported steel grew more slowly than the price of domestic steel, a calculation of the growth in auto value-added using domestic deflators would *overestimate* real growth in value-added.

The importance of these factors increased during the 1970s and early 1980s, a period of rising imports, huge increases in the price of oil coupled with tremendous decreases in the prices of computers, and sharp growth in services—an activity which is inherently difficult to deflate.

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[1] Milo Peterson, "Gross Product by Industry," *Survey of Current Business*, vol. 67, No. 4, April 1987.

[2] See David W. Cartwright, "Improved Deflation of Purchases of Computers," *Survey of Current Business*, vol. 66, No. 3, March 1986.

[3] A.G. Clem and W.D. Thomas, "New Weight Structure Being Used in the Producer Price Index," *Monthly Labor Review*, vol. 110, No. 8, August 1987, pp. 12-21.

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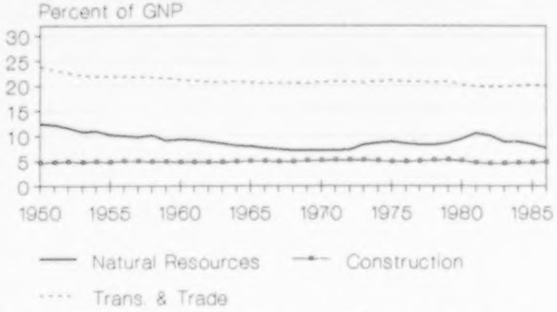
mix of businesses clustered as the "steel industry" may change as small "mini-mills" producing specialty products increase and the traditional large-scale mills producing bulk products decline.

Aggregation can also affect the analysis of what factors cause a shift in the share of a sector. Shifts that appear to result from changes in the production recipe induced by technological innovation may merely be due to changes in the industrial composition of a broadly defined sector.

Recent Trends in Sector Shares

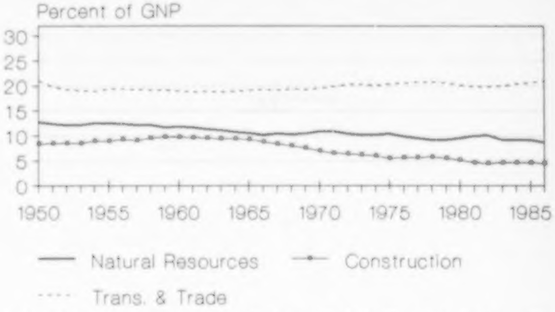
Figures 5-2a&b, 5-3a&b, and 5-4a&b summarize changes in relative shares of GNP held by the production sectors that have occurred in the U.S. economy over the past 35 years. A discussion of trends appears in box 5-C.

Figure 5-2a.-Current Dollar Shares of GNP for Natural Resources, Construction, and Transportation & Trade



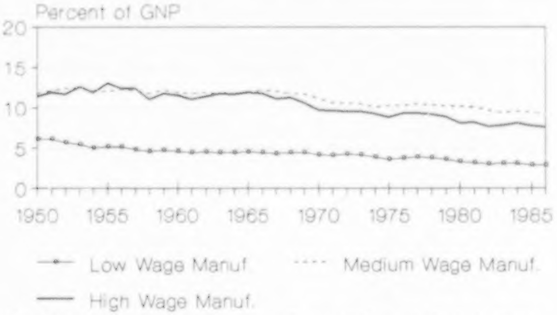
SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.1.

Figure 5-2b.-Constant Dollar Shares of GNP for Natural Resources, Construction, and Transportation & Trade



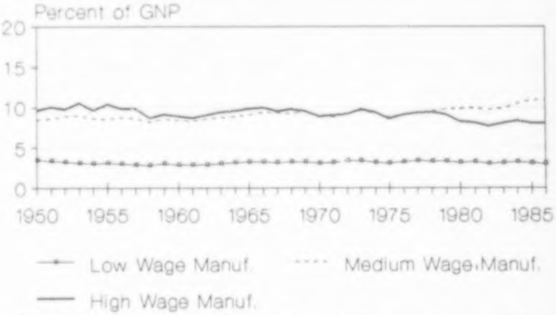
SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.2.

Figure 5-3a.-Current Dollar Shares of GNP for Low Wage, Medium Wage, and High Wage Manufacturing



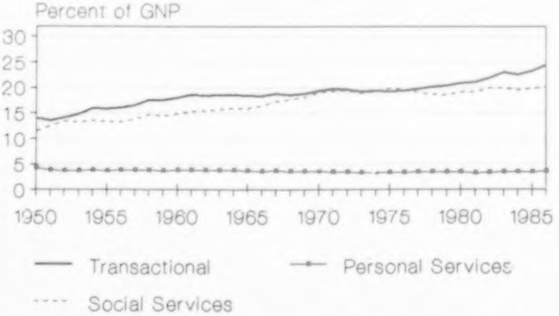
SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.1.

Figure 5-3b.-Constant Dollar Shares of GNP for Low Wage, Medium Wage, and High Wage Manufacturing



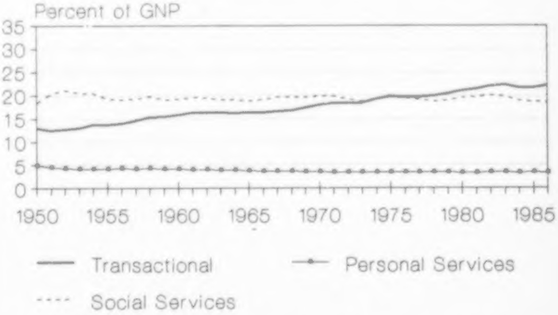
SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.2.

Figure 5-4a.-Current Dollar Shares of GNP for Transactional Activities, Personal Services, and Social Services



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.1.

Figure 5-4b.-Constant Dollar Shares of GNP for Transactional Activities, Personal Services, and Social Services



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.2.

Box 5-C—Shifting Shares of Value-Added in the U.S. Economy

Natural Resource Industries

One of the clearest structural trends in the U.S. economy has been the relative decline of the Natural Resource sector. This decline is reflected in both current and constant dollar shares of GNP.

The current dollar share has fallen from more than 12 percent to less than 9 percent—a 29 percent loss since 1950 (see figure 5-2a). This loss would probably have been much greater had oil and gas prices not quadrupled in the 1970s. The constant dollar share also declined steadily. Over three-quarters of the loss from 1950 to 1984 is attributable to the farm industry. Between 1972 and 1984, however, the constant dollar share of the farm industry remained unchanged; nearly 90 percent of the sectoral loss was due to declines in crude petroleum & natural gas and electric, gas, water, & sanitary services, reflecting the conservation and substitution of energy products.

Construction

The constant dollar share of Construction increased slightly more than 1 percent during the 1950s (see figure 5-2b). Because this was matched by gains in productivity, the current dollar share held steady. Since the mid 1960s, productivity growth has been small, and in some cases even negative. As a result, the current share has remained relatively stable while the constant share has declined, mainly in line with recent economic downturns; about one-fifth of the 30-year decrease occurred from 1973 to 1975, and another quarter occurred from 1979 to 1982.

Low Wage Manufacturing

Low Wage Manufacturing held a relatively stable share in constant dollars between 1950 and 1984, but lost half its share in current dollars (see figures 5-3a and 5-3b). The difference between constant and current share is attributable to the fact that Low Wage Manufacturing had strong productivity gains—gains driven in part by intense foreign competition.

Between 1972 and 1984, Low Wage Manufacturing's share of constant dollar GNP remained largely unchanged because of offsetting trends in different industries. Footwear and miscellaneous manufacturing (mainly composed of the jewelry and toy industries) declined, while lumber & wood products and apparel grew. The relatively large rubber & plastics and furniture & fixture industries kept a constant share.

Medium Wage Manufacturing

Medium Wage Manufacturing has lost nearly a quarter of its share measured in current dollars since 1950, but gained over a quarter in constant dollars (see figures 5-3a and 5-3b). As with the low wage sector, this discrepancy is due to steady gains in productivity. The three leading industries of this sector—non-electrical machinery, electric industrial equipment, and food & kindred products—experienced respective price increases that were 10, 28, and 27 percent below the 1970 to 1983 U.S. average.[1]

During the 1972-84 period, the increase in the constant dollar share of this sector resulted from industries characterized as "high-tech": electronic components, optical equipment, scientific instruments, and office, computing, & accounting machines. These four accounted for 73 percent of the growth of all industries in this sector that rose in share; office, computing, & accounting enterprises increased their share by a factor of almost 6 over the 12-year time period.

High Wage Manufacturing

The fate of High Wage Manufacturing is particularly important for the U.S. economy since, as the name suggests, it has long been a source of well-paid jobs. Its importance also lies in its strong links to the rest of the economy (see ch. 4). Nevertheless, the sector lost both constant and current dollar share of GNP (see figures 5-3a and 5-3b). The bulk of High Wage Manufacturing's loss in constant dollars occurred during the 1970s, a period of weak productivity growth for this sector and of increasing competition from foreign firms. The petroleum refining, primary iron & steel manufacturing, and motor vehicle industries were the major sources of this decline. Of the 20 industries included in this sector, only one, drugs, cleaning, & toilet preparations, witnessed any substantial growth, with most of that occurring between 1972 and 1977. Productivity in many high wage sectors has increased in the past few years, but average growth during the 1972-1984 period was slow.[2] The discrepancy between the shares reported in figure 5-3b and the share shifts calculated using the input/output methods described in chapter 4 is particularly great for this sector.

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[1] U.S. Bureau of the Census, *Statistical Abstract of United States, 1985* (106th ed.), Washington, DC, 1984, table 783.

[2] Ibid.

Transportation & Trade

Transportation & Trade is one of the largest sectors in the economy, responsible for approximately one-fifth of the Nation's GNP over the past 35 years. The sector's current dollar share has declined gradually since the mid 1950s, while the constant share has tended to rise (see figures 5-2a and 5-2b).

Individual industries, however, have experienced significant changes. Of the sector's 5-percent gross decline in current dollar share from 1950 to 1984, more than half was attributable to railroad transportation enterprises. On the other hand, air transportation enterprises were responsible for half of the gross increase. From 1972 to 1984 there was little change, although nearly all of this sector's growth in constant dollar share has come from the wholesale & retail trade industry. Wholesale & retail trade's contribution to GNP has historically been the largest of any industry; by 1984, its share was more than that of all industries contained in the Low and High Wage Manufacturing sectors combined.

Transactional Activities

No other sector has experienced the dramatic growth generated by the group of industries characterized as "transactional." The growth of this sector has been rapid and continuous since 1950, with both the current and constant share rising in unison until 1980 (see figures 5-4a and 5-4b). After 1980, however, the constant share leveled off while the current share continued to climb. This has probably been due to the escalation in real estate prices since 1979.[3]

Since 1972, the dominant growth industry within this sector has been business services, responsible for more than 40 percent of the increase in sectoral share. Real estate & rental also grew, contributing more than one-quarter of the constant share increase; this development made real estate the second largest industry, after wholesale & retail trade, in the 1984 U.S. economy.[4]

Personal Services

Losing share in both constant and current dollar terms, Personal Services are the exception to an otherwise dramatic shift towards a service-oriented economy (see figures 5-4a and 5-4b). The largest decline is located in the household services industry (domestic services), much of which has fallen prey to the introduction of labor-saving household appliances.[5]

Since 1972, the sector has maintained a stable constant dollar share. This balance was achieved through gains in the automobile repair & services and amusements industries, offsetting a continued decline in household services.

Social Services

The Social Service sector is comprised of the public and private health and education industries, as well as Federal and State government. This sector has grown dramatically over the past 35 years; in fact, it has the fastest current dollar growth rate of any sector, increasing by 70 percent between 1950 and 1984 (see figure 5-4a). State and local government enterprises were the main contributors to this current dollar growth, generating about half of the increase since 1950. The constant dollar share, however, only grew at the same rate as the economy. Part of this dichotomy can be attributed to weak gains in productivity; only the Personal Services and Construction sectors have shown less productivity growth than Social Services. The other factor involved is a sharp increase in prices.

Between 1972 to 1984, the combination of Federal, State, and local government decreased their share in constant dollars. Most of this loss was compensated for by a gain in share from private health, education, & social services.

can be isolated from other factors, by using 1980 production recipes to estimate industry output given patterns of final demand occurring in 1972, 1977, 1980, and 1984. In other words, the effects of final demand can be separated from those brought about by new recipe patterns, which tend to reflect changes in the technology of production. Table 5-2 details these changes.

Changes in the composition of final demand from 1972 to 1984 had a significant impact on the output produced by industries in several sectors, especially

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[3] Ibid., table 790.

[4] The National Income Accounts also impute a rental-equivalence value for home owners that is allocated to the real estate industry.

[5] Joe Schwartz, "The Goods Life," *American Demographics*, December 1987.

The changes may seem small at first. The share of Natural Resources, for example, fell from 13 percent in 1950 to about 9 percent in 1984—hardly a dramatic decline. It must be recognized, however, that given the size of the U.S. economy, even a one percent shift in GNP share is significant. In 1984, a 1 percent change in share meant $38 billion gained or lost. For comparison, the total compensation paid to all of the employees of the motor vehicle industry was $35 billion, and businesses spent $34 billion on computers, in 1984.[11]

Explaining the Changes

Which of the factors listed at the beginning of this chapter were responsible for the sectoral shifts described in figures 5-2, 5-3, and 5-4? Methods introduced in chapter 4 can be used to distinguish between changes resulting from new patterns of demand, new production recipes, and new patterns of international trade.[12]

In brief, changes in demand, both domestic and international, and changes in production recipes have had almost equal effects on the overall shift in share during the past decade, but the impact on individual sectors and industries varies widely. Not surprisingly, demand changes tend to have their greatest effect on industries that sell final, finished products, such as motor vehicles and real estate. Recipe changes affect industries such as oil, steel, chemicals, and business services, which typically supply goods or services that are then used as ingredients in a finished product. International trade has reinforced the changes generated by domestic demand and production recipes, but its effects were not pronounced until after 1980.

The period 1972 to 1984 was chosen for in-depth analysis. This is the most recent time frame for which consistent and detailed information could be assembled. It was an interesting period, characterized by major structural movements. Between 1972 and 1984, for example, oil and gas prices more than tripled, steel production fell by 30 percent, information processing equipment grew from 13 percent to over 40 percent of all durable equipment expenditures, and the ratio of imports and exports (gross) to GNP nearly doubled.

Table 5-1 summarizes the analysis of shifts in the share of constant dollar value-added contributed by ten sectors between 1972 and 1984, showing the extent to which the shifts were attributable to changes in production recipes as opposed to foreign and domestic demand.[13] The table is not intended to describe exact movements between sectors resulting from different factors, but to exhibit the relative magnitude of the different factors as part of sectoral change. In this sense, the table provides a sensitivity analysis and not a precise mapping of cause and effect.

Of the 8.9 percentage points of GNP that was exchanged between sectors gaining share and sectors losing share from 1972 to 1984, roughly half was attributable to changes in the production recipe and half was connected to changes in final demand. Within the broad category of final demand, the impact of domestic demand on changes in economic structure was—for the economy as a whole—more than twice as large as the impact of trade. Nevertheless, the impact of trade was still impressive, because most trade effects occurred over a relatively brief period—after 1980—while the effects of domestic demand have been relatively constant since 1972.

The Impact of Trade and Domestic Demand on Economic Structure

The effects of changing patterns of final demand on the changing shares of different business sectors

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[11] U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, vol. 67, No. 7, July 1987, tables 5.6 and 6.4B.

[12] "Demand" refers to final demand, or the purchase of goods and services for final consumption (see chs. 2 and 3). "Recipe" represents the intermediate demand for goods and services ("ingredients") that will be combined to create a final product (see ch. 4). For examples of using demand as a factor of change, see Robert Lawrence, *Can America Compete?* op. cit., footnote 2, and U.S. Department of Commerce, Office of Economic Affairs, "Trade Ripples Across U.S. Industries," Washington, DC, 1986. For analyses that focus on the role of "recipe," or technical coefficients in the process of structural change, see Anne Carter, *Structural Change in the American Economy* (Cambridge, MA: Harvard University Press, 1970) and Wassily Leontief and Faye Duchin, "The Impacts of Automation on Employment, 1963-2000," contract report for the National Science Foundation, Washington, DC, April 1984.

[13] The selection of any one year for a comparison point is fraught with the peculiarities of that particular year. This analysis uses 1972 and 1984 because they offer the widest time range given the available data, and because they are close to being the end points of their respective business cycles, effectively eliminating cyclical factors. Different endpoints can yield different effects attributable to "demand" and "recipe." See Stanley J. Feldman, David McClain, and Karen Palmer, "Sources of Structural Change in the United States, 1963-1978: An Input-Output Perspective," *The Review of Economics and Statistics*, 1987. The 1984 endpoint uses 1984 demand in conjunction with the 1980 Input-Output tables, and therefore does not completely reflect the 1984 economy.

Table 5-1.—The Sources of Structural Change: Change in Percentage of Constant Dollar Share of GNP From 1972 to 1984 by Sector (1980$)

(numbers will not necessarily add due to rounding and interactive effects)

	Natural Resources	Construction	Low Wage Manufacturing	Medium Wage Manufacturing	High Wage Manufacturing	Transportion & Trade	Transactional Activities	Personal Services	Social Services	Federal Defense	Other[a]
All	−2.3	−1.3	0.2	0.6	−3.3	2.0	5.5	0.1	0.4	−0.9	−1.1
Production recipe[b]	−0.9	−0.5	0.4	0.3	−2.3	0.6	2.6	0.2	−0.4	−0.0	0.0
Final demand	−1.4	−0.7	−0.3	0.5	−0.9	1.2	2.9	−0.1	0.8	−0.9	−1.1
Domestic demand[c]	−1.1	−0.8	0.1	0.7	−0.5	0.7	2.4	−0.2	0.6	−0.9	−1.0
Trade[d]	−0.4	0.1	−0.4	−0.3	−0.4	0.5	0.5	0.0	0.3	0.0	0.0
Interactive	−0.0	0.1	−0.0	0.2	0.1	−0.2	−0.0	−0.0	−0.1	0.0	0.0

How To Read This Table: Between 1972 and 1984, the percentage of all value-added in the economy generated by Natural Resource businesses fell 2.3 percentage points. This is equivalent to saying that Natural Resource contribution to GNP fell 2.3 percentage points. The decline resulted from new patterns of domestic demand (responsible for a 1.1 percentage point decline in the Natural Resource share), trade (0.4 percentage point), and production recipies (0.9 percentage point).

[a] Includes non-production, accounting industries such as non-comparable imports, scrap, rest of the world industry, and inventory valuation adjustment.

[b] Production recipe refers only to 1972 to 1980 change.

[c] Estimated from the 1984 National Income and Product Accounts (U.S. Department of Commerce).

[d] 1984 Trade data are estimated and rebased into 1980 dollars from data provided by the U.S. Bureau of Labor Statistics.

NOTE: All = Recipe + Final Demand + Interactive; Final Demand = Domestic Demand + Trade.

SOURCE: Office of Technology Assessment, 1988.

Table 5-2.—U.S. Structural Change Resulting From Changes in Final Demand
(constant dollar GNP-share for selected years of final demand; value-added shown by production sector and calculated using the 1980 I-O)

Production sectors	1972	1977	1980	1984[a]
Natural Resources	10.7	9.4	8.8	9.3
Construction	6.9	6.4	5.9	6.2
Low Wage Manufacturing	3.6	4.2	3.4	3.3
Medium Wage Manufacturing	9.5	10.0	9.8	10.0
High Wage Manufacturing	9.9	9.9	9.3	9.0
Transportation & Trade	18.2	18.9	19.5	19.4
Transactional Activities	20.7	23.1	23.3	23.6
Personal Services	3.8	4.0	3.7	3.7
Social Services	13.5	15.0	14.5	14.2
Federal Defense	3.0	2.3	1.9	2.1
Other	0.2	−3.2	0.0	−0.9
Total	100.0	100.0	100.0	100.0

[a] Output derived from demand estimated from the National Income and Product Accounts.

NOTE: Totals may not add to 100 due to rounding.

SOURCE: Office of Technology Assessment, 1988.

Natural Resources, High Wage Manufacturing, and Transactional Activities.

In the case of the Natural Resource sector, most of the shift due to final demand occurred between 1972 and 1977. Not surprisingly, the two industries affected were crude petroleum & natural gas and electric, gas, water, & sanitary services. For crude petroleum, most of the decrease was attributable to trade as imported oil replaced the output originating from domestic companies. In the case of electric, gas, & water services, nearly all the decrease was traced to lower domestic demand from domestic consumers.

The High Wage Manufacturing sector also experienced a significant reduction in share due to final demand. Half of this sector's loss in GNP share due to shifts in final demand came from the motor vehicle, iron & steel, and petroleum refining industries. The motor vehicle industry didn't start to lose share until after 1977, at which point the decline was primarily due to slack domestic demand from consumers and business. Trade was a relatively small factor for this industry until after 1980, when its negative effect almost eliminated what could have been a relatively large gain in share achieved through strong domestic demand. The iron & steel industry has suffered a fate similar to that of motor vehicles: the decline in share from 1977 to 1980 was of domestic origin; after 1980, domestic demand would have slightly increased this industry's share of GNP if not for a detrimental trade balance.

Although these are the major declining sectors, another sector, Low Wage Manufacturing, registered a small decline and is of interest because of the dominant effect trade has had on this sector. In a no-trade environment, five out of the twelve Low Wage Manufacturing industries would have gained in GNP share, resulting in a net gain for the sector over the period from 1972 to 1984. But the addition of trade reverses the trend, resulting in a decline in GNP for three-quarters of the industries. The industries that experienced the most dramatic turnaround in share due to trade were fabrics, textile goods, apparel, footwear, and miscellaneous manufacturing (which includes the production of jewelry, toys, and writing implements). By and large, these trade impacts have been felt since 1972, but they are most pronounced in the period from 1980 to 1984.

Construction's share of GNP fell over the 1972-84 period, due to declines in domestic demand for new construction. The defense sector also lost GNP share between 1972 and 1977, in part because of the end of the Viet Nam war. (The "value-added" in defense consists entirely of compensation paid to military employees.)

Balancing the decline of these sectors are four sectors that gained in GNP share as a result of changes in final demand: Transactional Activities, Transportation & Trade, Social Services, and Medium Wage Manufacturing. Of the four, Transactional Activities was responsible for gaining over 50 percent of the total share that shifted between 1972 and 1984 due to final demand. Four-fifths of this sector's gain can be credited to domestic demand, primarily consumer demand, the bulk of which has been fueled by consumer demand for the products of the real estate & rental and finance & insurance industries.[14]

Transactional Activities also benefited the most from international trade; about one-fifth of the sector's total gain due to demand came from trade. The industries that increased their GNP share because of trade were similar to the industries that benefited from domestic demand: real estate & rental and business services.

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[14] The real estate & rental industry includes a Commerce Department imputation for owner-occupied housing.

The Transportation & Trade sector gained share because of both trade and comparatively rapid growth in domestic demand. The wholesale & retail trade industry was responsible for most of the growth. Within this sector, eating & drinking places increased share particularly rapidly, primarily because of rapid growth in final demand.

Social Services also gained share because of changes in final demand. Most of the increase resulted from growing demand for the health, education, & social services industry. These increases offset a large decline in demand for the services of Federal, State, and local activities that occurred between 1972 and 1984. Ninety percent of this loss occurred after 1980.

Most of Medium Wage Manufacturing's increase derived from final demand came from industries that can be characterized as high technology: office, computing, & accounting machines; radio, TV, & communication equipment; and optical, ophthalmic, & photographic equipment. Domestic demand for these products, particularly from the business sector, was strong, but the negative effect of trade dampened what could have been impressive gains. Trade also contributed to a loss in GNP share for less technologically oriented industries like metalworking machinery and electronic components. Nearly all of this loss of GNP share due to trade occurred between 1980 and 1984, reversing a positive impact from trade achieved from 1972 to 1977.

The Impact of Production Recipes on Economic Structure

If changes in demand, including trade, account for roughly half of the total structural change in the economy, the other half can presumably be explained by changes in intermediate demand—the demand for goods and services used as ingredients in making a product for final consumption, a major component in the production recipe. Chapter 4 explained how this recipe changed between 1972 and 1980, revealing that service sector inputs had increased while inputs from the natural resource and manufacturing sectors decreased. How has this change in recipe affected GNP share?

The impact of changes in the production process can be seen by estimating how the output from different industries would change when production recipes vary—using those of 1972, 1977, and 1980—but leaving demand as it was in 1984. What would GNP look like if the production recipe of 1972 were used to satisfy demand for a car, compared to the recipe used in 1980? It must be recognized, of course, that the process of producing 1984 demand using a 1972 production recipe is highly artificial. For example, most industries would have used a dramatically different amount of oil in 1972 if the the price of oil in 1972 was as high as in 1980.

The procedure reveals that the impact of recipe on structural change was roughly the same as that of demand.[15] As table 5-3 shows, three of the five sectors with increasing share due to changes in recipe were the same three sectors that benefited from changes in demand—Transactional Activities, Transportation & Trade, and Medium Wage Manufacturing—although within these sectors, the individual industries that benefited differed widely from those gaining share due to final demand. Sectors losing share due to changes in both recipe and demand were High Wage Manufacturing, Natural Resources, and Construction. Most changes were therefore reinforcing rather than offsetting, although Low Wage Manufacturing and Personal Services proved to be exceptions; these sectors experienced a gain in share due to recipe, but lost as a result of demand. Social

Table 5-3.—U.S. Structural Change Resulting From Changes in the Production Recipe
(constant dollar GNP share derived from 1984 total final demand; by production sectors, using the 1972, 1977 and 1980 I-O adjusted to 1980$)

Production sectors	1972	1977	1980
Natural Resources	10.1	9.7	9.3
Construction	6.8	6.6	6.2
Low Wage Manufacturing	2.9	3.3	3.3
Medium Wage Manufacturing	9.7	10.0	10.0
High Wage Manufacturing	11.3	9.7	9.0
Transportation & Trade	18.8	19.4	19.4
Transactional Activities	21.0	22.0	23.6
Personal Services	3.5	3.6	3.7
Social Services	14.7	14.4	14.2
Federal Defense	2.1	2.1	2.1
Other	−0.9	−0.9	−0.9
Total	100.0	100.0	100.0

NOTE: Totals may not add to 100 due to rounding.

SOURCE: Office of Technology Assessment, 1988.

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[15] The time span is restricted to an 8-year period, 1972 to 1980, because of the availability of data.

Services lost share because of recipe shifts, but gained share because of demand.

The sector which lost the most due to changes in recipe was High Wage Manufacturing. Approximately 70 percent of the decline occurred between 1972 and 1977, and can be traced to three industries: petroleum refining, chemicals, and primary iron & steel manufacturing. These industries account for more than four-fifths of the 1972 to 1980 drop in High Wage Manufacturing's GNP share due to recipe changes. Unlike the situation resulting from changing demand, the motor vehicle industry experienced only a small reduction in share because of changing production recipes.

The changes in High Wage Manufacturing's share of GNP seem to have resulted from the increased availability of new materials, such as plastics, which can act as substitutes for steel;[16] the sharp increase in crude oil prices, which pushed up the price of chemicals and refined petroleum products and thus forced a recipe change; and the influx of foreign intermediate inputs as ingredients in the production recipe.

The share lost by High Wage Manufacturing due to recipe changes was primarily absorbed by Transactional Activities. The Transactional sector picked up nearly two-thirds of the shift in share that occurred between 1972 and 1980 due to recipe change. Growth was strong from 1972 to 1977, but even stronger from 1977 to 1980; presumably, a 1984 recipe would indicate that this sector gained even more. The business services industry, which includes activities such as advertising, legal services, and computer and data processing services, was responsible for nearly 70 percent of the sectoral increase;[17] the finance & insurance industry came in a distant second.

Production recipe changes resulted in a sharp increase in demand for Transactional Activities—business services in particular. As discussed in chapter 4, more complex business networks seem to require larger numbers of transactions, resulting in more demand for services like those provided by lawyers and consultants. Decisions to contract out services that were previously done "in-house" and increasing geographic dispersion of production also result in an increase in Transactional Activities.[18] For example, many manufacturing firms now contract out for janitorial services that had been performed internally. Although the actual amount of this work has not necessarily increased, it appears to grow because it is now counted as an "arms-length" market transaction.[19]

The impact of changed production recipes on sectors other than High Wage Manufacturing and Transactional Activities is rather small. Most of the decline among Natural Resource industries was located in agricultural products (non-livestock), and in electric, gas, water, & sanitary services. Changes in recipe also had a negative effect on the share of Construction, particularly in the new construction industry. The last sector to experience a loss of share due to recipe changes was Social Services, with most of the loss attributable to the health, education, & social service industry.

After Transactional Activities, the sector that gained the most in terms of share due to recipe changes was Transportation & Trade. The wholesale & retail trade industry was responsible for most of the increase gained by this sector. This is not surprising, considering the increased role that marketing now plays in the delivery of a product, and the fact that constant dollar per capita retail sales grew by 23 percent between 1972 and 1984.[20]

Unlike the situation in High Wage Manufacturing, both Low and Medium Wage Manufacturing benefited from changes in the recipe of production. In the low wage sector, the industries devoted to apparel and lumber & wood products achieved the greatest gains. For Medium Wage Manufacturing, the principle industries behind the gain in sectoral share were office, computing, & accounting machinery and electronic components (mostly semiconductors).

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[16] Stanley J. Feldman and Karen Palmer, "Structural Change in the United States: Changing Input-Output Coefficients," *Business Economics*, January 1985, p. 43.

[17] For a more detailed analysis of the changing role of the business services industry in the recipe of production, see Feldman and Palmer, op. cit., footnote 13; Bobbie H. McCrackin, "Why Are Business and Professional Services Growing so Rapidly?" *Economic Review*, Federal Reserve Bank of Atlanta, August 1985; and John Tschetter, "Producer Services: Why Are They Growing So Rapidly?" *Monthly Labor Review*, vol. 110, No. 12, December 1987, pp. 31-41.

[18] McCrackin, op. cit., footnote 17, and Tschetter, op. cit., footnote 17.

[19] Richard B. McKenzie, "The Emergence of the Service Economy: Fact or Artifact?" policy analysis No. 93, Cato Institute, Washington, DC, Oct. 27, 1987.

[20] U.S. Bureau of the Census, *Statistical Abstract of the United States, 1986* (106th ed.), Washington, DC, 1985, table 1388.

In the case of computers and electronic components, the reasons for an increase in share due to recipe change are apparent. During the 1970s, the computer became an accepted element in the production process; as time goes on, adoption, adaptation, and implementation of computer technologies in the workplace is certain to increase. The reason behind the growth of apparel as an intermediate input is less obvious, except perhaps for the fact that the Multifiber Arrangement, which allows for trade agreements that restricted fiber imports into the United States (and other developed nations), took effect in 1974; some researchers have found that these trade restrictions had a positive effect on domestic output.[21] The increase in the output of the lumber industry is probably due to the role lumber plays as an input in housing production, and the fact that new housing starts for the 1972-84 period peaked in 1972-73 and 1977-78.[22]

Tracing the Significance of Structural Change

It is difficult to pass judgement about whether changes in sectoral share of GNP are desirable or undesirable. Much of the remainder of this document is devoted to tracing the way shifting production recipes effect U.S. responses to trade, opportunities for employment, and the net productivity with which the economy delivers amenity to consumers. Chapter 7 traces the relationship between trade and sector contributions. Chapter 10 shows how changing production recipes affect demand for different kinds of jobs.

Patterns of change in sector shares (including the surprisingly constant share of manufacturing) have not changed radically for many decades. On the other hand, a prolonged period of slow change can have a major cumulative effect. After reaching a threshold, what seemed like a gradual process may suddenly be seen as a transition. This threshold is more likely to be perceived in periods of slow economic growth than in periods of strong growth, where downward fluctuations are masked by general prosperity.[23]

The issue is not whether structural change is occurring at any greater or lesser rate that it has in the past. In some areas it has and in others it has not. The critical point is that the collective effect of three decades of change has left the United States with a much different economy.

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[21] U.S. Congressional Budget Office, *Has Trade Protection Revitalized Domestic Industries?* (Washington, DC: U.S. Government Printing Office, November 1986), p. 32.

[22] *Statistical Abstract of the United States 1986*, op. cit., footnote 20, table 1297.

[23] James H. Crossing and Arye L. Hillman, op. cit., footnote 5.

CHANGES IN SCALE AND SCOPE

The second kind of structural change to be examined involves the way business networks are owned and managed, in terms of the size, or *scale*, and the product mix, or *scope*, of their operations. This analysis is critical because different patterns of scale and scope shape the ability of a business to compete in international markets, dictate the quality and stability of the jobs offered, and determine the success with which new technologies can be exploited.

One of the difficulties in any discussion of this kind is that there is no good vocabulary for describing the variety of ways that business networks in an economic sector are organized. One source of confusion is the distinction between an "establishment" and an "enterprise." The word enterprise (sometimes also called a firm) indicates an independently owned corporate entity. An establishment is a specific plant, branch, or subsidiary within an enterprise. A large enterprise may consist of many small establishments.

Beyond this distinction, there are a variety of patterns in which business networks can be organized. The following is a partial list:

- Sectors dominated by a small number of large firms that either:
  —concentrate their activities in a single plant or a comparatively small number of plants (e.g., the old Ford Motor Co. Rouge River Plant);
  —maintain tightly managed subsidiaries and branch offices, where managers of distinct components are not given appreciable flexibility (e.g., branches of major insurance companies); or

  - —have the dominant form of organization through loosely controlled establishments, subsidiaries, or franchises, in which the establishment's management is given considerable autonomy and is compensated primarily on the basis of decisions made as an independent agent (e.g., a branch bank manager with freedom to establish his or her own loan criteria).
- Sectors dominated by one or more large firms that effectively regulate a market for a large collection of small, independent firms (e.g., IBM sets de-facto standards for a wide variety of personal computer equipment and software systems produced by many different firms; similarly, the firms formerly part of the old Bell system set standards for a host of other communications suppliers).
- Sectors dominated by small firms operating independently, which are either:
  - —nominally independent, but constrained by their product or by a lack of research to behave as though they were producing mass-produced commodities (e.g., farms, teaching, and home construction); or
  - —independent entrepreneurs, providing imaginative responses to new markets and new production technologies. Such firms may pool research or marketing through trade associations (an example might be the semiconductor industry in Silicon Valley).

Given the difficulty of developing an acceptable taxonomy, there is no easy way to trace patterns of change. Moreover, firms in traditionally fragmented sectors (e.g., farms, physicians, and home builders) are amalgamating into larger units, while sectors that were traditionally highly concentrated (e.g., automobile production) are turning to networks of small and medium-size suppliers for a greater share of parts and engineering services.[24]

It appears extremely unlikely that the new form of industrial organization will bear much resemblance to the "new industrial state" that seemed so inevitable a generation earlier.[25] While small firms may provide invaluable sources of innovation, it appears equally unlikely that significant growth will originate from small firms unless they are able to work together in a way that at least approximates the economies of larger enterprises—small firms now command a declining share of output in virtually every sector of the economy. However, they play an important role by providing employment when few other alternatives are available, and provide a large share of jobs added during economic recessions (e.g., as carpenters and machinists become self-employed repairmen or work in retail stores).[26]

Under current circumstances, small firms are able to provide growing employment opportunities by offering comparatively low wages, few if any non-wage benefits, comparatively poor working conditions, and weak job security. While parts of Italy and West Germany may have created an environment where networks of small firms can avoid many of these liabilities, the growing share of U.S. employment in smaller businesses, coupled with a shrinking share of assets, profits, and sales, may lead to the growth of a two-tier system in the United States. Workers finding stable employment in comparatively productive large firms may do increasingly well, while their counterparts in small firms do increasingly poorly.

Economic success now appears to depend increasingly on technical innovation, but little is known about how the scale and scope of businesses influence rates of innovation. Entrepreneurs may alone be able to grasp a truly revolutionary concept; the merits of semiconductors were almost universally ignored by firms with a large stake in the manufacture of vacuum tubes, and the merits of microcomputers were not initially recognized by firms with large interests in mainframes. But groups of entrepreneurs are able to manage large markets only in exceptional cases. In the semiconductor and microcomputer "shake-out," survivors have typically grown to become large enterprises or have been absorbed by large firms.

Industrial structure in major sectors clearly results from private management decisions, but these decisions are strongly influenced by public policy and in many cases are the conscious result of public policy. Private decisions about mergers, pooling of research, foreign marketing, adoption of communications and other standards, contributions to retraining programs, and other actions that shape the way large business networks are managed, are all strongly influenced by Federal and State policy—directly through formal regulation, and indirectly through tax laws and other macroeconomic decisions.

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[24] Michael S. Flynn, "Out-Sourcing Rediscovered," *IEEE Spectrum*, vol. 24, No. 10, October 1987, pp. 46-49.

[25] See John Kenneth Galbraith, *The New Industrial State* (New York, NY: New American Library, 1971).

[26] Bruce E. Kirchhoff and Bruce D. Phillips, "Examining Entrepreneurship's Role in Economic Growth," paper delivered at the Seventh Annual Babson Entrepreneurship Research Conference, Malibu, CA, April 30, 1987.

Describing Changes in Scale and Scope

Changes in scale and scope affect both individual firms and the establishments of which they are composed. For example, insurance firms are delegating more authority to small sales offices located throughout a region, while they are consolidating record keeping and other functions. Large construction firms are combining property development, mortgage financing, factory construction of components, and site erection. General Motors has a finance division, GMAC, that provides loans for buyers of GM cars. Even though the creation of this division is an expansion of scope, because it is directly tied to new car sales, it does little to insulate GM from falling sales. To counter this problem, GM has proposed another expansion of scope by which it will begin to offer home equity loans—a business divorced from cars. This diversification of products can lower costs, as fixed investments are amortized over a broader base of products.

There is clear evidence that the growth of large firms is increasingly built around the aggregation of many comparatively specialized small establishments. As a result of these developments, many large firms claim that they are reorganizing operations to encourage more entrepreneurial behavior on the part of individuals and establishments. Techniques range from large rewards for inventors and patents (IBM can award $10,000 or more for an important innovation) to the AT&T system for encouraging venture business, in which employees can earn both salary and profits from new projects and can even invest personal funds or defer part of salaries. The firm reports that it has already received 2,000 proposals.[27]

Obviously, a radical change in corporate philosophy is needed before established, hierarchical firms will be willing to tolerate real entrepreneurial behavior. While GM claims to have encouraged its production establishments to shop for price and quality, in practice the assembly operations appear to be forced to give preference to Central Foundry Division for castings, Rochester Products Division for fuel systems, and Delco Moraine Division for brakes. These GM subsidiaries regularly win long-term contracts because they are allowed to bid without including overhead, capital, and other fixed expenses. GM's inability to escape rigid vertical integration, and the comparative flexibility of Ford and Chrysler, has been cited as an explanation for GM's recent loss of market share.[28]

A large firm, or a set of firms, can also provide a de facto set of standards and regulations to organize the activity of a large number of smaller "satellite" enterprises.[29] The dominating firm can operate at a variety of places in the system, tying resources to final markets, and can be a producer, such as IBM, a retailer, such as Safeway, or a mixture of both, such as health maintenance organizations. Other examples include large hospital chains and group practices, which are capturing markets once enjoyed by fragmented private practices and local unaffiliated hospitals; these firms are often innovators in medical practices designed to reduce costs. Small community banks, caught in a changing regulatory environment that has spurred the need to broaden their product mix and enhance their technical expertise, are forming partnerships with larger regional banks.[30]

Small, independently owned firms can form effective networks through a series of free market contracts, but their performance can often be enhanced by cooperating in areas of mutual interest such as research and development, training, and overseas marketing. The ability to create some of these consortia is difficult for U.S. firms because of antitrust laws and entrenched business cultures, but they have been used effectively in Japan, West Germany, and Northern Italy.[31]

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[27] R.M. Kanter, "The Attack on Pay," *Harvard Business Review*, vol. 65, No. 2, March-April 1987, pp. 60-67.

[28] W. Hampton and J.R. Norman, "General Motors: What Went Wrong," *Business Week*, No. 2990, Mar. 16, 1987, p. 102.

[29] The term is used by Michael Piore and Charles Sable, *The Second Industrial Divide* (New York, NY: Basic Books, 1984).

[30] Dwight B. Crane and Robert C. Eccles, "Commercial Banks: Taking Shape for Turbulent Times," *Harvard Business Review*, vol. 65, No. 6, November/December 1987, pp. 94-100.

The problem of defining "large" and "small" firms or "concentrated" and "competitive" sectors has become increasingly difficult given the growth of national and international production networks. While antitrust considerations were formerly needed to consider whether a firm monopolized regional markets, should they now consider the scale of firms with respect to international markets?

Forces of Change

Changes in scale and scope are driven by the same four forces that lead to changes in sectoral contributions to GNP: technology, rules and regulations, patterns of domestic demand, and international competition.

Technology

Changes in industrial organization are made possible by radical improvements in the way information can be communicated among firms and establishments, and by changes in technology that greatly reduce the size at which economies of scale become important. The availability of inexpensive computer-assisted design (CAD) and computer-assisted manufacturing (CAM) technologies operating on personal computers has allowed even small machine shops to adopt these innovations, reducing waste, errors, and down time. The time to convert a customer's drawing to a cutting die, for example, has fallen by a factor of seven.[32] Even small metal fabrication facilities can make use of technologies such as Flexible Manufacturing Systems, which operate at a minimum scale of six machines and a half dozen people.[33] Large data entry and typing pools are disappearing as data entry is integrated into other functions distributed throughout the firm.

Communications technologies have rewritten many rules, providing unprecedented opportunities for uniting small enterprises into a dynamic framework.[34] Production technologies capable of tailoring products to specialized markets without a significant sacrifice in productivity or increase in cost can vastly diminish the value of economies of scale.[35] Of course, small subsidiaries of large firms may still be favored over independent firms that lack access to sophisticated communication networks. But there are instances where smaller enterprises, tied to an independently operated information network, can enjoy new life because of a close relationship with national and international markets. A national data network, for example, may help small-scale U.S. farmers who produce high value products, such as fruits or specialized vegetables, to bid on the international market. Advances in telecommunications allow companies like American Airlines to take advantage of cheap labor in Barbados for data entry, saving the company about $3.5 million per year.[36]

Regulation

Formal changes in regulations have had a profound effect on patterns of business organization throughout the economy, particularly in transportation, health, and communications. Changed regulation in transportation created an explosion (possibly of short duration) of independent owner-operators, as well as the formation of integrated transportation firms such as Federal Express—which combines truck pickup and delivery, air freight, and telecommunications. Health regulations have encouraged the formation of health maintenance organizations and consortia of physicians. The breakup of AT&T has, of course, fragmented a sector once organized exclusively under a regulated monopoly.

The interpretation of antitrust regulation (the Sherman Act, the Clayton Act, and the Federal Trade Commission Act) is also in flux (see box 5-D). These rulings plainly have a strong influence on business structure. Rapid growth in conglomerate as opposed to horizontal mergers undoubtedly resulted in part

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[31] Danielle Mazzonis and Mario Pianta, "An Innovation Strategy for Traditional Industries," draft report prepared for the industrial association of Prado, Italy, September 1986.

[32] *Mechanical Engineering*, January 1987, p. 6.

[33] See R. Jaikumar, "Postindustrial Manufacturing," *Harvard Business Review*, vol. 64, No. 6, November/December 1986, p. 76; and *Mechanical Engineering*, op. cit., footnote 32. This issue is discussed at greater length in the manufacturing section of ch. 6.

[34] Werner Neu, Karl-Heinze Neuman, and Thomas Schnoring, "Trade Patterns, Industry Structure, and Industrial Policy in Telecommunications," *Telecommunications Policy*, March 1987.

[35] The advent of "mini-mills" in the steel industry is a good example of this phenomenon. See Bela Gold, "Technological Change and Vertical Integration," *Managerial and Decision Economics*, vol. 7, 1986.

[36] Bruce Stokes, "Beaming Jobs Overseas," *National Journal*, vol. 17, No. 30, July 27, 1985, p. 1726.

Box 5-D.—Anti-Trust Regulation Affecting Mergers and Acquisitions

"That no person engaged in commerce or any activity affecting commerce shall acquire, directly or indirectly, the whole or any part of the stock or other share capital [where] . . . the effect of such acquisition may be substantially to lessen competition, or to tend to create a monopoly."

The Clayton Act, Sec. 7 (15 U.S.C., Sec. 18 (1980))

"Every contract, combination in the form of trust or otherwise, or conspiracy in restraint of trade or commerce among the several states, or with foreign nations, is hereby declared to be illegal."

The Sherman Act, Sec. 1 (15 U.S.C., Sec. 1 (1975))

"Unfair methods of competition in or affecting commerce, and unfair or deceptive acts or practices in or affecting commerce are hereby declared illegal."

Federal Trade Commission Act, Sec. 5 (15. U.S.C., Sec. 435 (1982))

SOURCE: Compiled in W.D. Appler, "Mergers in the Food Industry: The Impact on FTC Regulation," paper delivered at the The Food Update Conference of the Food and Drug Law Institute, "Mega-Mergers: The Impact of Consolidation," Tampa, FL, April 1987.

from the Cellar-Kefauver Act.[37] Antitrust law has been amended to permit research consortia designed to promote U.S. competitiveness, though the act has failed to stimulate much real collaborative research.

Liberal interpretations of anti-trust statutes have virtually eliminated formal barriers to mergers during the Reagan administration. In 1986, for example, 2,406 pre-merger filings were made pursuant to the Hart-Scott-Rodino (HSR) Act, three times the rate of applications in 1979. Of these, 2,108 were approved without further inquiry by granting requests for early termination of the statutory waiting period. The rest were issued letters requesting further information, and 25 HSR filings were made. The Federal Trade Commission filed court papers in only three cases between 1979 and 1985—Pepsico's proposed acquisition of Seven-Up, Kidde's proposed acquisition of Horneschfeger (mobile hydrolic cranes), and Conoco's proposed acquisition of Asamera. And in one of these cases, a consent order settled the issue before a suit was filed.[38]

Demand

If changes in scale and scope are made possible by new regulations and new technologies, they have also been made necessary by both dramatic changes in domestic demand and a massive invasion of imported products. There may once have been a period when large U.S. manufacturers could in effect ignore market dynamics by creating markets for their products, through advertising in a product market (like automobiles) dominated by a small number of domestic firms. This pattern of performance was encouraged by a long period of post-war business successes and government programs designed to create a climate favorable for growth built around oligopolistic activity. To some extent, the emergence of large manufacturing firms meeting relatively homogeneous markets resulted from the limitations of production technology; they may also have been encouraged by a political process that equated this form of industrial organization with progress and growth.[39] Organized labor shared this vision, since large, centrally managed firms and predictable markets provided a sound basis for stable employment. However, high levels of concentration can be justified by the economies of scale derived from large-scale operations in only a few industries.[40]

Times have changed. Growing affluence and new technologies make it necessary to substitute niche markets for relatively homogeneous ones for products ranging from automobiles to health care (see ch. 3). Firms that ignore how their products connect with the consumer are increasingly at peril. If nothing else, the demand for dynamic performance (an ability to react quickly to both opportunity and disaster) has outstripped the importance of static performance (low cost in a predictable environment).[41]

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[37] John M. Connor, "Mergers in the Food Industry: Trends, Effects, and Policies," staff paper No. 87-9, Department of Agricultural Economies, Purdue University, March 1987, p. 2.

[38] W.D. Appler, "Mergers in the Food Industry: The Impact on FTC Regulation," paper delivered at the The Food Update Conference of the Food and Drug Law Institute, "Mega-Mergers: The Impact of Consolidation," Tampa, FL, April 1987.

[39] Piore and Sable, op. cit., footnote 29.

[40] Bruce E. Kaufman, "Scale of Plant Relative to Market Size in U.S. Manufacturing," *Southern Economics Journal*, October 1979, vol. 46, No. 2.

[41] Burton Klein equates dynamic productivity with an ability to take advantage of good luck and recover from bad luck. See Burton Klein, *Dynamic Economics* (Cambridge, MA: Harvard University Press, 1977).

Radically changed perceptions about the desirable scale of electric power-generating facilities provides a particularly clear example. Large 1,000-MWe plants may have been able to produce power less expensively when they were commissioned in the 1970s, but their economic success depended critically on levels of demand for electricity projected over a 20-year period. Massive mistakes in estimates have left many regions with large, unused generating capacity. Few utilities are now willing to gamble on 20-year forecasts, and are willing to pay a premium for small units that can be added to as needed. At the same time, advances in electric generating technology like steam-injected gas turbines may make it possible for 100- to 200-MWe plants to compete with larger plants without incurring the risks associated with uncertainty.[42]

Foreign firms have called into question traditional patterns of domestic business management never seriously questioned by domestic competition. Dynamic, entrepreneurial firms making semiconductors in California's "Silicon Valley" find themselves overwhelmed by oligopolies managed by greying bureaucrats in Japan. Large U.S. manufacturers of automobiles find themselves with lower productivity than Japanese production facilities one-third their size. Large U.S. textile machinery firms find their markets picked to pieces by an invasion of aggressive producers from West Germany that work harder to identify market niches. U.S. farmers find their export surplus overwhelmed by imports of such products as Italian tomatoes and Brazilian orange juice.

With the exception of declines in farming (a sector dominated by small businesses) each of the forces at work would tend to increase the role of comparatively small establishments if past trends continue. There are now more points of entry for smaller, specialized enterprises; small firms have moved alertly into businesses such as software development, maintenance and repair of communication and computational equipment, and computer-generated graphic design. Such firms traditionally flourish during periods of rapid transition, since the bureaucratic inertia of large firms may blind them to opportunities in places where none were expected. Who could have imagined a business built around graphics for personal computers a decade ago? The rules of the game are changing rapidly.

Measuring Changes in Scale and Scope

Scale

Small employers appear to be providing an increasing fraction of jobs but a declining fraction of output.[43] The largest firms, however, appear to be expanding mainly by aggregating large numbers of comparatively small branches, or subsidiaries, which are typically involved in different kinds of businesses.

Small businesses, defined here as employing 100 people or less, accounted for 98 percent of all U.S. business enterprises and 34 percent of all employment in 1984.[44] The average firm size dropped from 26.2 employees in 1976 to 21.7 in 1982. Although large firms created 1 million more jobs than small firms between 1976 and 1984, table 5-4 indicates that in relative terms most growth occurred in mid-size firms, those employing between 20 and 500 people. The smallest firms (less than 20 employees) maintained their share of U.S. employment while the largest firms (more than 500 employees) lost share.

The role of small business depends heavily on the sector examined. An auto plant employing only several hundred workers would be considered small, whereas several hundred lawyers would represent

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[42] Eric D. Larson and Robert H. Williams, "Steam-Injected Gas Turbines," *Journal of Engineering for Gas Turbines and Power*, January 1987; Eric D. Larson and Robert H. Williams, "Steam-Injected Gas Turbines and Electric Utility Planning," *Technology and Society*, March 1986.

[43] Measuring the scale of a firm involves relying on empirical measures like jobs, assets, or output—all of which are very sensitive to definitions of "small" or "large," the data source used and its coverage, and the methodology employed. In particular, some controversy has arisen over the role small business plays in the job generation process and the accurate classification of a business as a small *establishment* or a small *enterprise*. See Catherine Armington and Marjorie Odle, "Sources of Job Growth: A New Look at the Small Business Role," *Economic Development Commentary*; vol. 6, No. 3, fall 1982; David L. Birch, "The Job Generation Process," MIT Program on Neighborhood and Regional Change, Cambridge, MA, 1979; Candee S. Harris, "Small Business and Job Generation: A Changing Economy or Differing Methodologies," working paper prepared for the Brookings Institution, February 1983; Sue Birley, "Finding the New Firm," *1984 Proceedings of the Academy of Management*, Boston, MA, August 1984; A.L. Walton, "How Small Businesses Contribute to Job Generation—The Pitfalls of a Seemingly Simple Question," paper presented at the 1983 Conference on Industrial Science and Technological Innovation, Evanston, IL, May 1983.

[44] Nearly all of the data in this discussion come from various editions of U.S. Small Business Administration, *The State of Small Business* (Washington, DC: U.S. Government Printing Office, 1984 and 1986 editions).

Table 5-4.—U.S. Employment by Firm Size: 1975-84 (percent of all jobs)

Firm size (number employed)	1975	1978	1980	1982	1984
Under 20	27.1%	26.6%	26.0%	26.8%	27.1%
20 - 99	26.9	27.9	28.3	28.5	28.8
100 - 499	22.6	23.2	23.8	23.5	23.5
500 - 999	8.0	7.9	7.6	7.3	7.2
Over 1,000	15.4	14.4	14.3	14.0	13.4
Total	100.0	100.0	100.0	100.0	100.0
Number of jobs	60,565	70,289	74,836	74,297	77,996[a]

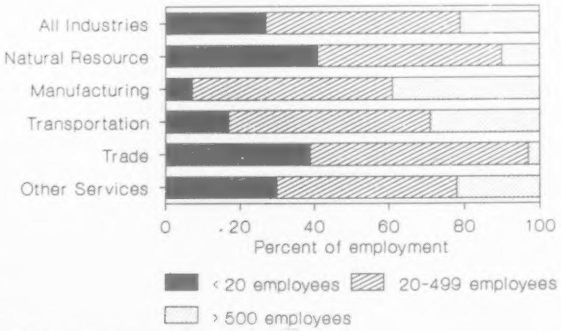
NOTE: Totals may not add to 100 due to rounding.

SOURCE: U.S. Bureau of the Census, *Statistical Abstract of the United States, 1987* (107th ed.), Washington, DC, 1986, table 858.

a very large law firm. Figure 5-5 indicates, for example, that manufacturing and transportation industries have a comparatively large share of firms with more than 500 employees while natural resource businesses, retail & wholesale trade, and "other services" have a comparatively large share of business with fewer than 20 employees.

With the exception of the retail industry, the rate of job growth in firms with fewer than 20 workers was faster than average during the period when the economy was entering the recession of the early 1980s, while growth was slower in firms with more than 500 (see table 5-5). Indeed, 56 percent of all manufacturing jobs added between 1976 and 1982 were found in firms with fewer than 20 workers, even though such firms represented only 7 percent of all employment in 1976 (the average number of employees per establishment, however, remained roughly the same for all sizes). And more than 46 percent of jobs added in the finance industry were in firms with less than 20 employees, despite the fact that these firms represented only 19 percent of all employees in 1976.

Figure 5-5.-Employment by Establishment Size and Industry in 1984



NOTE: Natural Resources includes Construction.

SOURCE: U.S. Bureau of the Census, *Statistical Abstract of the United States: 1987* (107th ed.), Washington, DC, 1986, table 859.

There were two important exceptions. The market share of builders with volumes greater than 100 housing units per year grew from 6.9 percent in 1959 to 67 percent in 1986, while the share of builders with volumes less than 25 units per year fell from 70 to 11 percent during the same period.[45] Similarly, more than 50 percent of all jobs added in retailing between 1976 and 1982 appeared in firms with more than 500 employees, even though such firms employed less than one-third of all retail employees in 1976.

Changes in patterns of self-employment also illustrate the changing scale of American enterprises. Table 5-6 documents a steady decline in self-employment, with the most significant changes occurring between 1950 and 1970. This drop was led by sharp losses in self-employment in retail trade. Self-employment in agriculture remains relatively high, but is steadily declining. The creation of owner-operator trucking and bus companies, made possible by deregulation, has presumably been responsible for the recent increases in self-employed transportation workers. The decline of self-employment in business and social services seems to have halted, but recent gains must be viewed with caution since they may represent a response to the most recent business cycle and not a long-term trend. Surprisingly, self-employment has increased in manufacturing since 1970, although the share of self-employed persons in manufacturing remains low.

In terms of assets, sales, and creation of GNP, large businesses continue to dominate and gain share. In

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[45] National Association of Home Builders, *Profile of the Builder*, Washington, DC, 1979; and "Housing Focus," November 1987.

Table 5-5.—Percent Change in U.S. Employment (by size of firm, 1976-82)

	Total change	Change by number employed:			
		1-19	20-99	100-499	500+
Agriculture, Forestry, & Fishing	4.9%	21.8%	−7.7%	−10.9%	−13.8%
Mining	37.6	72.1	52.3	59.2	24.1
Construction	7.9	24.8	−2.1	−14.1	−1.4
Manufacturing	5.3	42.7	10.7	2.1	1.1
Transport, Communication & Utilities	13.0	33.9	11.4	8.1	10.3
Wholesale trade	15.2	28.8	8.2	12.7	4.7
Retail trade	15.6	9.5	10.7	20.4	24.6
Finance, Insurance & Real Estate	19.3	46.6	14.3	7.6	13.9
Services	29.3	52.6	26.2	19.6	26.2
All Industries	15.6	29.3	13.1	10.7	12.2

SOURCE: U.S. Small Business Administration, *The State of Small Business* (Washington, DC: U.S. Government Printing Office, 1985), table A1.21.

Table 5-6.—U.S. Self-Employment by Industry (percent of all full-time equivalent employment in that industry)

Industry	1950	1960	1970	1975	1980	1986
Agriculture, Forestry, & Fishing	67.7	61.3	58.9	54.9	52.4	50.1
Mining	3.4	4.0	2.2	2.1	2.7	3.3
Construction	29.4	19.7	16.7	19.9	22.0	22.8
Manufacturing	2.6	1.9	1.4	1.5	1.8	2.0
Durable goods	2.8	2.0	1.5	1.7	1.8	2.0
Nondurable goods	2.3	1.7	1.2	1.4	1.8	2.0
Transport, Communications & Utilities	4.8	4.5	4.2	5.0	5.5	6.0
Wholesale trade	9.2	8.4	6.3	5.8	5.4	5.1
Retail trade	25.5	21.8	13.3	12.3	11.6	9.2
Finance, Insurance, & Real Estate	10.3	8.8	6.9	7.7	8.4	8.4
Services	19.5	18.5	15.9	14.7	14.0	13.9
Total	19.6	15.3	11.1	11.1	10.9	10.7

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 6.7b and 6.10b.

1977, firms employing more than 500 people represented only 0.4 percent of all businesses but were responsible for 53 percent of all value-added in the economy.[46] In 1985, manufacturing firms with more than $1 billion in assets held nearly 70 percent of all corporate assets and firms with more than one billion dollars in annual profits enjoyed nearly 70 percent of all U.S. corporate profits.[47] Moreover, the Nation's largest businesses had sales that grew faster than the sales of small businesses between 1976 and 1982 in spite of the increase in small business employment. Firms with more than 10,000 employees produced sales growth of 16 percent annually from 1976 to 1982,[48] while firms with between 10 and 19 employees saw their sales grow an average of 14 percent and other businesses with fewer than 500 employees averaged between 4.3 and 9.0 percent sales growth. This continued a trend already evident between 1958 and 1977.[49]

Most of the expansion of large businesses, however, appears to have occurred through net creation of new establishments rather than expansions of old ones. Seventy percent of the new jobs emanating from large businesses originated from net additions of establishment startups minus closings, and not from expanding existing establishments.[50] From 1976 to 1984, small businesses (under 100 employees), commonly thought of as the source of new establishments, derived only 60 percent of their (net) new jobs through this source (see figure 5-6).[51]

Figure 5-7 shows the dramatic growth in the number of establishments owned by large firms. This addition of establishments corresponds to the fact that the largest increase in the share of jobs was not in small establishments owned by small firms, but in small establishments owned by large firms.[52]

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[46] See "The Changing Industrial and Size Composition of U.S. Business," *The State of Small Business*, op. cit., footnote 44, 1984. p. 118.

[47] *Statistical Abstract of the United States 1987*, op. cit., footnote 20.

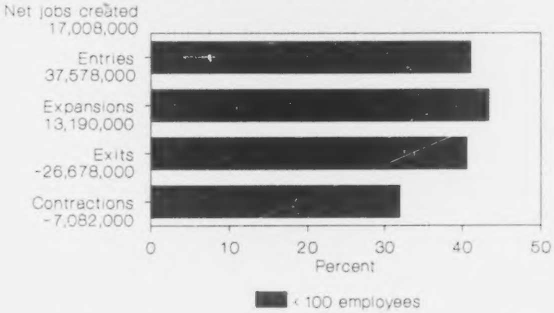
[48] *The State of Small Business*, op. cit., footnote 44, 1984, p. 67.

[49] Ibid., p. 134.

[50] U.S. Small Business Administration, Office of Advocacy, Small Business Data Base, USEEM File, table 4, unpublished data, April 1987.

[51] Bruce E. Kirchhoff and Bruce D. Phillips, op. cit., footnote 26.

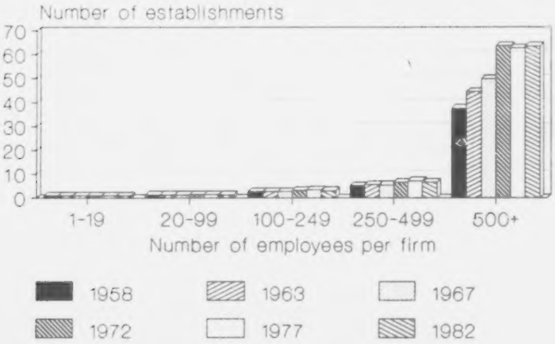
Figure 5-6.-Composition of 1976 to 1984 Employment Changes by Type of Change for Firms With Fewer Than 100 Employees



How To Read This Figure: Of all the jobs created by new firms that started businesses between 1976 and 1984, about 40% were created in firms with less than 100 employees.

SOURCE: U.S. Small Business Administration, Office of Advocacy, "Small Business Data Base," USEEM File, unpublished data, 1987.

Figure 5-7.-Average Number of Establishments per Firm by Firm Size



How To Read This Figure: In 1958, the average firm with 500 or more employees owned 37 establishments ("firms" indicate ownership, "establishments" are separate plants). By 1972, firms with more than 500 employees owned more than 60 establishments, and owned approximately the same number in 1982.

SOURCE: U.S. Small Business Administration, *The State of Small Business: A Report of the President* (Washington, DC: U.S. Government Printing Office, March 1984), table A2.20.

Scope

While large firms may be producing many different products, individual establishments within these firms, as well as small independent establishments, appear to be specializing rather than diversifying. Independent manufacturing establishments showed particularly strong movement toward specialization.[53]

It is difficult to determine whether large firms are assembling specialized operations in order to achieve economies of scale, for reasons having to do with the investment interests of owners, or for the way the component establishments work together. Most recent mergers in manufacturing and mining are classified as "conglomerates" (see table 5-7); the heterogeneity of the firms being assembled into large businesses could suggest that mergers are not being undertaken to improve integrated efficiencies.[54] On the other hand, firms might be diversifying into different components of their respective systems or networks (buying an airline as well as holding a rental-car company and a hotel chain) while retaining economies of scale at the establishment level.[55] Several manufacturers have begun to sell intermediate products like machine tools and software, in addition to using them in their own operations.

Rather than fitting into the traditional notion of forward or backward integration, this spinning-off of new products reflects a diagonal movement that crosses traditional technological and industry boundaries.[56] It has been noted, for example, that "per dollar spent, airlines make more money on reservation systems than they do on flying passengers."[57] An analysis of the food industry, which has experienced more than 5,000 mergers and acquisitions from 1975 to 1985, concluded that most of the mergers were undertaken to ". . . market complementary products, create new products from combined know-how, and distribute the weaker merger partner's products through a stronger sales network."[58] Given the com-

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[52] Growth rates were calculated for the 1978 to 1982 time period. *The State of Small Business*, op. cit., footnote 44, 1984, p. 15.

[53] Frank M. Gollop and James L. Monohan, "From Homogeneity to Heterogeneity: A Proper Index of Diversification," *Technical Notes*, U.S. Department of Commerce, Bureau of the Census, Washington, DC, October 1986, p. 22.

[54] Ibid., p. 2.

[55] Ibid., p. 29.

[56] Bela Gold, op. cit., footnote 35.

[57] Helen Wheeler, "Air Reservations: New Savvy in the Skies," *High Technology Business*, vol. 7, No. 11, November 1987, pp. 36-40.

[58] William D. Appler, op. cit., footnote 38.

Table 5-7.—Merger Trends in Manufacturing and Mining, 1948-79

	1948-53	1956-63	1963-72	1973-77	1978	1979
Horizontal	36.8	19.2	12.4	15.1	28.5	2.3
Vertical	12.8	22.2	7.8	5.8	15.1	7.3
Conglomerate	50.4	58.6	79.8	79.1	56.4	90.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

SOURCE: Frank M. Gollop and James L. Monohan, "From Homogenity to Heterogeneity: A Proper Index of Diversification," Bureau of Census Technical Notes, U.S. Department of Commerce, Washington, DC, September 1984.

plex assembly of service and production operations that must be combined to deliver products to markets, traditional definitions of vertical integration are difficult to apply and may be inappropriate.

In manufacturing enterprises, it is clear that firms are diversifying production through holding a more varied portfolio of establishments that are producing a more homogeneous mix of products. Using an index that measures the number of different products produced by an establishment, it can be shown that manufacturing establishment diversification fell by a factor of nearly 3 from 1963 to 1982.[59] The diversity of products made by individual *establishments* fell in 17 of 20 major manufacturing categories examined.[60] In contrast, diversification of manufacturing *enterprises* increased during the period in 14 of 20 industries. Since 1963, this level of diversification has increased by 15 percent.[61]

By 1984, 12 percent of manufacturing employment was in establishments not classified as manufacturing. These non-manufacturing establishments owned by manufacturing firms had an employment growth rate of 6 percent between 1982 and 1984, compared to a loss of 1 percent in the manufacturing establishments.[62]

Consequences of Changes in Scale and Scope

There is a rich literature describing the relationship between business size, management strategies, and dynamic performance, and a small theoretical literature covering economies of scope is beginning to appear.[63] Unfortunately, most of this developing work deals with manufacturing firms, not with enterprises whose primary output is information or other "non-products."

The following discussion will concentrate on how new technologies may act to challenge the rules that have governed forms of business organization. Three classes of implications are considered:

- Will the emerging structures be more aggressive in their pursuit of invention and innovation, and will they be more likely to adopt innovations when they occur?
- Will they be more or less likely to efficiently match resources to amenity needs?
- Will the new systems be more attractive to employees in that they permit greater stability, higher pay, or more unpaid benefits?

Are Smaller Firms More Inventive?

Are smaller firms more likely to exploit the advantages of innovation and force changes in market structures because larger firms are too sluggish or are immobilized by institutional inertia and complacent management? Or are large firms more likely to take advantage, since they are better able to undertake long-term research and transform the payoff from innovation into a cycle that produces more innovation? Both may be correct. Periods dominated by entrepreneurial activity ~~may~~ alternate with periods dominated by large firms.[64] It is also possible that both trends occur simultaneously in different parts of the economy. The critical question for this analysis is whether the U.S. economy is moving into a period where research is unusually beneficial to large, bureaucratic firms, or unusually likely to depend on and encourage the emergence of small, innovative ones.

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[59] Gollop and Monohan, op. cit., footnote 53, p. 29.

[60] Ibid., p. 25

[61] Ibid., pp. 25, 26, 29.

[62] Marjorie Odle and Catherine Armington, "Is American Manufacturing Creating Jobs Again?" unpublished working paper, Applied Systems Institute, p. 3.

[63] See C. Freeman, J. Clark, and L.L.G. Soete, *Unemployment and Technical Innovation* (Westport CT: Greenwood Press, 1982); J.K. Galbraith, op. cit., footnote 25; Morton I. Kaimen and Nancy L. Schwartz, *Market Structure and Innovation* (Cambridge, England: Cambridge University Press, 1982); F.M. Scherer, "Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions," *American Economic Review*, vol. 55, No. 5, 1965, p. 1097; and L.L.G. Soete, "Firm Size and Inventive Activity: The Evidence Reconsidered," *European Economic Review*, No. 12, p. 319; Woodward, Lawrence, and Lorsch, *Organization and Environment* (Boston, MA: Harvard University Press, 1967); T. Burns and G.M. Stalker, *The Management of Innovation* (London: Tavistock, 1961); E.F. Fama, "Agency Problem and the Theory of the Firm," *Journal of Law and Economics*, 1980, vol. 88, pp. 288-307.

A useful review of all this literature is provided by Ronald W. Cotterill, "The Economic Efficiency of Alternative Forms of Business Enterprise," Storrs Agricultural Experiment Station, Staff Paper No. 85-10, U.S. Department of Agriculture, 1985.

Michael Piore and Charles Sable argue that the pendulum has swung back to a situation favorable to the entrepreneurial model.[65] This argument suggests that the conventions which formed the basis for prosperity under the "Fordist" model of industrial structure—and the entire structure of private and public regulation that supported it—have been fatally eroded by new technology and the challenge of foreign trade. As a result, the system must move either in the direction of smaller, more flexible, more entrepreneurial institutions that are regulated by the market, or toward greater international regulation of concentrated markets. A number of factors can act as barriers to innovation in large-scale operations: top management isolation, intolerance of eccentric ideas, short-time horizons, narrowly defined accounting objectives, and inappropriate incentives.[66] Large U.S. firms have also been accused of lethargy, inattentiveness to the market, and a bureaucratic structure that prevents flexibility and innovation.[67]

Large firms may go through periods of stagnation and renewal without the challenge of entrepreneurial firms. The U.S. automobile industry, for example, was challenged not by small entrepreneurial competitors but by foreign competition. After a period of relative complacency, this industry has recently been forced to re-examine an enormous range of accepted conventions, and may soon enjoy a "renaissance" unshaken by domestic competitors.[68]

Another complication is posed by several qualitative factors that defy precise measurement. Technologies developed by small firms tend to move rapidly into the hands of larger enterprises, whose ongoing research establishments—and possibly better management, marketing, and production engineering capabilities—are able to translate innovation into business success. And as chapter 9 will show, many of the large firms capitalizing recently on the ideas of small, innovative U.S. businesses have been foreign-owned.

Small companies face particularly serious problems during periods of generally poor business performance. As Piore and Sable argue, while smaller firms may be in a better position to respond quickly to new market conditions by adjusting output and wages—sometimes because they face little or no union opposition—they also face formidable obstacles. Small manufacturing firms tend to have relatively high capital costs;[69] the U.S. Small Business Administration estimates that on average, small businesses pay a premium that is 2 to 3 percent higher than capital rates charged to larger firms.[70] Combined with external debt, high capital costs often make operating a small enterprise particularly difficult during bad times. Entrepreneurs may be tempted to react by selling intellectual assets, which can constitute the core of their comparative advantage.

As has been noted, a "large firm" covers an enormous variety of management styles and structures. Some are collections that are in essence financial portfolios, others are combinations with a functional theme. Networks of specialized enterprises may provide the basis for real flexibility,[71] and enhanced flexibility is a crucial ingredient in fostering innovation.[72]

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[64] A. Phillips, *Technology and Market Structure* (Lexington, MA: Lexington Books, 1971); Christopher Freeman, *The Economics of Industrial Innovation* (Cambridge, MA: The MIT Press, 1982), 2d ed., p. 210. Even Schumpeter seems to have changed his mind on the subject. Drawing on the experience of 19th century capitalists, his 1912 book emphasized the importance of the entrepreneur for bringing inventions to the market. His revised view published in 1943 emphasized the importance of large firms.

[65] Piore and Sable, op. cit., footnote 29.

[66] James Brian Quinn, "Managing Innovation," *Harvard Business Review*, vol. 63, No. 3, May-June 1985, pp. 76-77.

[67] See interview with Malcolm Baldrige, "Despite Barbs, Baldrige Hopeful on U.S. Business," *Washington Post*, Dec. 7, 1986; Quinn, op. cit., footnote 66; and Charles Sabel, "How To Keep Mature Industries Innovative," *Technology Review*, vol. 90, No. 3, April 1987, pp. 27-35.

[68] William Abernathy, *Industrial Renaissance: Producing a Competitive Future in America* (New York, NY: Basic Books, 1983).

[69] W.M. Cohen, R.C. Levin, and D.C. Mowery, "Firm Size and R&D Intensity: A Re-examination," National Bureau of Economic Research, Cambridge, MA, working paper No. 2205.

[70] *The State of Small Business*, op. cit., footnote 44, 1986.

[71] See Peter B. Doeringer, "Make Way for Mature Industries," unpublished paper delivered at the 1987 IRRA Spring Meeting; and Quinn, op. cit., footnote 66, p. 4.

[72] L. Balcerowicz, "Organizational Structure of the National Economy and Technological Innovations," *Acta Oeconomica*, No. 24., 1980.

On the other hand, a "boutique" structure may prove too fragmented to be efficient.[73]

An argument can also be made that the continual process of reshuffling national assets through mergers can drain talent and capital from more productive investments.[74] From 1980 to 1985, the amount spent on mergers and acquisitions was more than double the level of industry financed research and development. In the last 6 years, General Electric has spent more than $12 billion acquiring 325 new businesses while divesting itself of 225 businesses for a sale price of $8 billion.[75] There is a danger that firms with a comparatively long-term planning horizon—large investments in research and development, and comparatively heavy capital investment—may be the targets of take-overs by firms attempting to realize short-term gains. If so, such mergers could be disastrous to any national strategy built around long-term commitment to innovation and worker training.[76] The key question is whether the transactional costs associated with forming new business structures lead to long-term savings, in the form of both lower transaction costs as a result of greater economies of scale and scope and more productive use of capital.

Empirical support for any of these theories has been difficult to develop. Some data suggest an inverse relationship between innovation and formalization (the number of rules and specified procedures).[77] Clearly, larger firms are responsible for the lion's share of all research conducted in industrial nations. Some experts argue that there are "irreversible dynamic scale economies"—once a technology begins to return significant income, firms that benefit initially can then re-invest their profits and multiply their initial advantage, set de facto standards, and effectively dominate the market.[78] Nearly 60 percent of all the research reported in the United States during the 1970s was conducted by the Nation's 20 largest firms; more than 90 percent was conducted by firms with more than 5,000 employees.[79] On the other hand, there is only a weak correlation between research intensity and firm size as measured in employment or sales. Small firms apparently generate more patents per R&D dollar than larger ones, and small entrepreneurs are more likely to patent an idea than large enterprises.[80] And a study looking for correlations between firm size and R&D intensity determined that most differences between firms can be explained by factors unrelated to size. Some manufacturing sectors pursue research aggressively while others failed to do so.[81]

Studies of the correlation between productivity and firm size yield similarly ambiguous results. An extensive analysis of labor productivity and multi-factor productivity gains between 1947 and 1972 indicates that larger firms' productivity growth has increased more rapidly that smaller firms.[82] Another study concludes that the rate of earnings per dollar of assets decreases as the size of the firm increases.[83] Moreover, empirical explanations of correlations between firm size, market concentration, and productivity growth provide few insights into how each of these variables affects the ability of firms to conduct research, invest in new plant and equipment, and train employees.

Table 5-8 suggests that if innovation is measured by the number of new products produced in a specific year per million dollars' worth of sales or R&D, then small firms are the most innovative. However, this measure assumes that all new products are equally important, and fails to adjust for the fact that many small business innovations (particularly "high-tech" developments) are spin-offs from large businesses.[84] The National Science Foundation states that the " . . . popular notion of the solo inventor operating in a basement is largely fiction;"[85] that those innovations having a significant social impact will

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[73] "Can America Compete?" *Business Week*, No. 2995, Apr. 20, 1987.

[74] See James W. Brock, "Bigness Is the Problem, Not the Solution," *Challenge*, vol. 30, No. 3, July-August 1987, pp. 11-25.

[75] Tom Peters, "Business in the Future Sense," *Washington Post*, Oct. 4, 1987.

[76] "Debate Between T. Boone Pickens and Lester C. Thurow," *The Energy Journal*, vol. 8, No. 2, 1986.

[77] J. Rothman, *Planning and Organizing for Social Change: Action Principles from Social Science Research* (New York, NY: Columbia University Press, 1974).

[78] Paul David, Presentation at the Symposium on Economics and Technology, Mar. 17-19, National Academy of Sciences, Palo Alto, CA, 1985.

[79] Freeman, op. cit., footnote 64, p. 132.

[80] Ibid., p. 136.

[81] W.M. Cohen, R.C. Levin, and D.C. Mowery, op. cit., footnote 69.

[82] Steven Lustgarten, *Final Report to U.S. Small Business Administration on Firm Size and Productivity* (Washington, DC: U.S. Government Printing Office, September 1982), pp. 16-17.

[83] Stahrl W. Edmunds, "Organizational Size and Efficiency in the U.S.," *The Antitrust Bulletin*, fall 1981.

[84] L. Tornatzky, et al., *The Process of Technological Innovation: Reviewing the Literature* (Washington, DC: U.S. Government Printing Office, 1983), p. 178.

[85] Ibid.

Table 5-8.—New Products First Marketed in 1982 by Size of Firm

Firm size ($ millions of net sales)	Number of products per $ million of net sales	Number of products $ million of R&D
Less than 100	0.113	3.76
100 - 350	0.067	2.17
350 - 1,000	0.027	1.49
1,000 - 4,000	0.010	0.66
4,000 and more	0.007	0.59
All firms	0.045	1.75

SOURCE: National Science Foundation, *Science Indicators: 1985* (Washington, DC: U.S. Government Printing Office, 1987), p. 262.

probably require a concentration of experts; and that the implementation of that technology will require a centralized means of production.

It is virtually impossible to measure gains resulting from mergers, or to distinguish mergers motivated by tax advantages or managerial hubris from those designed to provide real gains in productivity or production flexibility.[86] A review of recent literature concluded that there was not sufficient empirical evidence to support or refute the notion that mergers result in efficiency gains.[87] Nevertheless, the number and value of both friendly and hostile mergers have increased dramatically in the 1980s (see figure 1-16 of ch. 1). While the effect of friendly mergers on employment and wages appears to be benign,[88] and while mergers can play a useful role as a catalyst for restructuring an industry, forcing managers to be responsive to shareholder interests,[89] the effect of *hostile* takeovers can also shift wealth from stakeholders (communities and employees) to shareholders with little net gain to society.[90]

A study of recent takeovers could not demonstrate that the takeover targets were more likely to be those with a long-term planning horizon, high cash flows, or low debt. In fact, the statistics indicated that compared with average firms, takeover targets had low investments in R&D, low capital/earnings ratios, and were virtually indistinguishable from the average firm in terms of cash flows and debt/equity ratios.[91]

Meeting Amenities

The relationship between the size and scope of enterprises in a sector and the facility with which firms can identify and reach new markets with new products in some ways mirrors the relationship between structure and innovation. But innovation in production technology by individual firms neither guarantees that the firms in a sector will work effectively together in marketing products, nor assures that they will be effective in discovering new consumer markets. Chapter 6 will address this issue in detail.

Employment

The discussion of large versus small firms also overlooks the quality of jobs associated with different levels of scale. Large businesses typically provide better wages, better non-wage compensation, and greater job stability.[92] Sectors characterized by a few dominant firms supported by a series of satellite firms can achieve great flexibility by forcing smaller firms to absorb gains and losses. Ways of achieving flexibility without such a high human cost are discussed in chapters 11 and 12.

Firms employing more than 500 workers pay 41 percent of their workers $10.00 or more per hour, compared to the U.S. average of 30 percent and the small business (25 to 99 employees) rate of only 23 percent.[93] In respect to providing health benefits to workers, firms with less than 25 workers provided this benefit to only 39 percent of workers, compared to the economy-wide average of 67 percent and the large business (more than 500 employees) rate of 85 percent. The probability of a worker becoming unemployed and remaining unemployed from a small firm (less than 100 employees) is higher than that of an employee of a large firm.[94]

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[86] J.M. Connor, op. cit., footnote 37.

[87] David J. Ravenscraft and E.M. Scherer, "Life After Takeover," Federal Trade Commission Working Paper No. 139, Washington, DC, February 1986; Julian Allen, "Mergers and Their Impact on Today's Economy: A Survey," U.S. Congressional Research Service, Report No. 82-118E, Washington, DC, 1982; and Julian Allen, "Corporate Takeovers: A Survey of Recent Developments and Issues," U.S. Congressional Research Service, Report No. 87-726E, Washington, DC, 1987.

[88] Gail McCallion, "Mergers and Acquisitions: The Impact on Labor," U.S. Congressional Research Service, Report No. 87-705E, Washington, DC, 1987.

[89] Michael C. Jensen, "Takeovers: Their Causes and Consequences," working paper, Harvard Business School, Cambridge, MA, August 1987.

[90] Andrei Shleifer and Lawrence H. Summers, "Breach of Trust in Hostile Takeovers," National Bureau of Economic Research, working paper No. 32, Cambridge, MA, August 1987.

[91] J. Pound, K. Lehn, and G. Jarrell, "Are Takeovers Hostile to Economic Performance?" *Regulation*, vol. 10, No. 1, September/October 1986, p. 23.

[92] See Edward M. Miller, "Large Firms Are Good for Their Workers: Manufacturing Wages as Function of Firm Size and Concentration," *The Antitrust Bulletin*, spring 1981.

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[93] *The State of Small Business*, op. cit., footnote 44, 1986, Table C.18, p. 248.

[94] Ibid., table C.17, p. 247.

THE GEOGRAPHY OF ECONOMIC ACTIVITY

The growth of complex production networks is also reshaping the location of America's economic activity. In the 1930s, it was still possible to predict the location of most economic activity by looking at a map of the United States showing only major geological and topographic features. Manufacturing was clustered around sources of raw materials, energy, and access to heavy transportation. Service activity was centered at the transfer points connecting transportation systems—river junctions and ports. Very little economic activity in the United States is now limited by such constraints.

Improved communications technology and the declining significance of natural resources increases options for both manufacturing and service establishments. Instead of spreading wealth and economic activity more evenly around the country, however, the changes appear to have resulted in a greater concentration of economic activity. Growth has been particularly rapid in regions immediately surrounding major coastal cities. Only scattered empirical evidence exists to explain these phenomena. It appears that concentration results from:

- a sustained need for personal (rather than electronic) communication;
- relatively rapid transportation within metropolitan areas, and comparatively easy access to other regions if needed or desired;
- a continuing interest in the comparatively good educational institutions often associated with major cities; and
- the fact that people seem to prefer the cultural opportunities and variety of living near a major metropolitan center.[95]

The forces that would lead to greater concentration in an economy where services play a large role have been known for some time. Writing in 1960, Raymond Vernon noticed that:

> The most probable outcome of the increased freedom offered by swifter air travel will be the further concentration of the office elite at a few headquarters cities. This tendency will be fortified by the use of high-speed electronic data-processing machines. For these machines will contribute to the centralization of data-processing and decision-making at fewer points in the structure of the giant company.[96]

Some service activities, such as health, education, and food service, are necessarily spread in rough proportion to population density, though chapter 6 documents a number of cases where even this tradition is changing: health care industries may centralize the sophisticated "tertiary care" hospitals while decentralizing out-patient services; technology may also permit greater geographic decentralization of large university campuses.

Transactional services and manufacturing, however, are now able to become more footloose. Transactional service industries, which provide a growing share of all employment, appear to have used the potential of communications technology to decentralize most of their activities, giving rise to a complex structure of enterprises. Insurance firms are centralizing functions ranging from record-keeping to processing such relatively undifferentiated products as home and auto insurance, but are decentralizing other work to local sales offices capable of conducting sophisticated analysis and underwriting with computer terminals. The dispatching of trucks may be centralized, while the ability to serve geographically dispersed freight customers increases.

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[95] M.L. Moss, "Telecommunications: Shaping the Future," paper prepared for the Conference on America's New Economic Geography, Washington, DC, Apr. 29-30, 1987.

[96] Raymond Vernon, *Metropolis 1985* (Cambridge, MA: Harvard University Press, 1960), p. 84, cited in M.L. Moss, op. cit., footnote 95. See also J. Gottman, "Megalopolis and Antipolis: The Telephone and the Structure of the City," in Ithia de Sola Pool,(ed.), *The Social Impact of the Telephone* (Cambridge, MA: The MIT Press, 1977).

In manufacturing, the emergence of comparatively small batch production, just-in-time inventory systems, and a need to participate in tightly linked networks supplying goods for retail outlets may encourage greater decentralization of activity. At the same time, these factors can lead to more centralized control over production, since sophisticated communications systems and comparatively lightweight products make it possible to operate a geographically dispersed network with increasing efficiency. The ability of multinational firms to build responsive production networks around the world is a case in point. (See discussion in ch. 7.)

Changes in the geography of economic activity have a number of indirect effects on the operation of the U.S. economy, including:

- influencing the price and quality of housing, since decentralization of employment can lower the cost of housing within a reasonable commuting range of work;
- changing options for improving productivity in transportation—with few exceptions, job growth has been highest in suburbs and geographic regions poorly served by public transportation;
- affecting opportunities for career growth, to the extent that "back office" functions are geographically segregated in suburbs while opportunities for advancement are most likely to be found in central offices located elsewhere; and
- undermining job stability and making union organization more difficult, as more and more jobs appear in service and manufacturing firms able to move locations with comparative ease in search of attractive labor pools.

Two kinds of change are discussed in the following section: first, relative changes in population, employment, and income growth in different parts of the country; and second, a continued economic movement to a constellation of population centers roughly associated with major cities, though not to urban centers themselves.

Regional Movements

Defining the Change

Measured in terms of population growth rates, table 5-9 indicates that cities on or near the east and west coast and in the southwest dominated U.S. urban growth during the period 1970-86 as well as 1985-86. Indeed, coastal metropolitan areas appear to be drawing the greatest benefit from the increasing importance of transactional services to total U.S. output (outlined earlier in this chapter), a development that has been reinforced by the relative rise of the transactional sector as a source of U.S. jobs (see ch. 10).[97] New York City, for example, continues to act as an international center for finance, advertising, and the arts, while Los Angeles is also becoming a major center for finance and trade with its easy access to Asia and Latin America.

At the the same time, sharp population declines continued in the major manufacturing centers of the midwest, particularly those affected by automobile and steel manufacturing. This development might have been expected since the share of U.S. output generated by manufacturing industries paying high wages—which contribute a large share of employment throughout the midwest—has dropped considerably over the past 15 years. (Again, see discussion of changes in value-added share by production sector earlier in this chapter.)

Looking at developments throughout the United States in terms of personal income, the convergence of regional income that characterized the 1950-70 period appears to have stopped, and in some cases has been reversed, during the 1980-85 period. As the east and west coasts continue to dominate major transactional services, States along the Atlantic coast have regained their advantage in incomes since 1980—a reversal of the trend during the previous decade (see figure 5-8). Moreover, the south Atlantic region has joined the northeast and California as a relative growth region; it appears that the Boston-Washington corridor is spreading south.

Personal income per capita in New England and the middle eastern States—which fell relative to the

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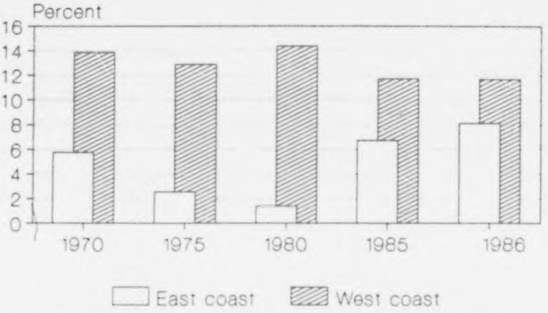
[97] See discussion of the impact of both trade and transactional services on metropolitan areas in Thierry Noyelle, "A New Economic Order," *Forum for Applied Research and Public Policy*, vol. 2, No. 1, winter 1987, pp. 97-105.

Table 5-9.—Population Growth of Major U.S. Metropolitan Areas

Population growth 1970-1986	Thousands	Annual percent	Population growth 1985-86:	Thousands	Percent
Largest gains:			***Largest gains:***		
Los Angeles-Anaheim-Riverside, CA CMSA	3,094	1.70	Los Angeles-Anaheim-Riverside, CA CMSA	337	2.65
Houston-Galveston-Brazoria, TX CMSA	1,465	3.28	Dallas-Fort Worth, TX CMSA	143	4.07
Dallas-Fort Worth, TX CMSA	1,303	2.79	Atlanta, GA MSA	89	3.60
San Francisco-Oakland-San Jose, CA CMSA	1,125	1.34	Phoenix, AZ MSA	83	4.57
Miami-Fort Lauderdale, FL CMSA	1,024	2.75	Washington, DC-MD-VA MSA	73	2.09
Phoenix, AZ MSA	929	4.28	San Francisco-Oakland-San Jose, CA CMSA	70	1.21
Atlanta, GA MSA	877	2.65	San Diego, CA MSA	68	3.19
San Diego, CA MSA	843	3.06	Philadelphia-Wilmington-Trenton, PA-NJ-DE-MD	57	0.99
Tampa-St. Petersburg-Clearwater, FL MSA	808	3.49	New York-Northern New Jersey-Long Island, NY	50	0.28
Denver-Boulder, CO CMSA	609	2.53	Tampa-St. Petersburg-Clearwater, FL MSA	45	2.41
Washington, DC-MD-VA MSA	523	1.00	San Antonio, TX MSA	40	3.24
Seattle-Tacoma, WA CMSA	448	1.37	Seattle-Tacoma, WA CMSA	38	1.69
Orlando, FL MSA	445	4.37	Miami-Fort Lauderdale, FL CMSA	34	1.18
Sacramento, CA MSA	443	2.66	West Palm Beach-Boca Raton-Delray Beach, FL MSA	33	4.56
West Palm Beach-Boca Raton-Delray Beach, FL MS	407	4.95	Sacramento, CA MSA	33	2.62
Largest losses:			***Largest losses:***		
Pittsburg-Beaver Valley, PA CMSA	−240	−0.61	Pittsburgh-Beaver Valley, PA CMSA	−21	−0.90
Cleveland-Akron-Lorain, OH CMSA	−234	−0.51	Cleveland-Akron-Lorain, OH CMSA	−10	−0.36
New York-Northern New Jersey-Long Island, NY	−225	−0.08	Peoria, IL MSA	−8	−2.30
Detroit-Ann Arbor, MI CMSA	−187	−0.25	Davenport-Rock Island-Moline, IA-IL MSA	−6	−1.59
Buffalo-Niagara Falls, NY CMSA	−167	−0.82	Buffalo-Niagara Falls, NY CMSA	−6	−0.51
Dayton-Springfield, OH MSA	−41	−0.27	Beaumont-Port, LA MSA	−5	−1.31
Youngstown-Warren, OH MSA	−27	−0.32	Huntington-Ashland, WV-KY-OH MSA	−4	−1.29
Utica-Rome, NY MSA	−25	−0.48	Utica-Rome, NY MSA	−3	−0.94
Milwaukee-Racine, WI CMSA	−23	−0.09	Youngstown-Warren, OH MSA	−3	−0.58
Flint, MI MSA	−11	−0.16	Saginaw-Baw City-Midland, MI MSA	−3	−0.74
Springfield, MA MSA	−10	−0.12	Rochester, NY MSA	−2	−0.20
Johnstown, PA MSA	−9	−0.22	Erie, PA MSA	−2	−0.71
Binghamton, NY MSA	−6	−0.14	Knoxville, TN MSA	−2	−0.34
Peoria, IL MSA	−2	−0.04	Charleston, WV MSA	−2	−0.74
Saginaw-Baw City-Midland, MI MSA	3	0.05	Johnstown, PA MSA	−2	−0.78

SOURCE: U.S. Department of Commerce, Bureau of the Census, CB87-116, Washington, DC, July 24, 1987.

Figure 5-8.-Per Capita Income of Coastal States (percent above national average)

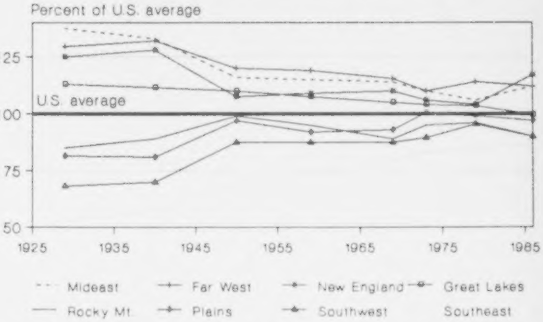


How To Read This Figure: People living in States on the U.S. east coast in 1970 averaged nearly 6% more income than the national average per capita income. By 1980 per capita income in these States was only 1.8% above the national average, but by 1986 it had increased so that the east coast averaged 8% more income per capita than the national average.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "Regional Economic Information System," tables SA1, SA2, and SA3, unpublished, August 1987.

national average during the 1970s—rose sharply in the early 1980s and is now significantly above the national average (see figure 5-9). The far west has maintained a comparatively high level of per capita income through the period. Incomes in the major manufacturing centers of Ohio, Illinois, Indiana, Michigan, and Wisconsin (the Great Lakes region), which were above the national average in 1970, fell below the national average in 1985 for the first time. Incomes in Texas, Oklahoma, Arkansas, and Louisiana (the southwest), which had begun to approach the national average, fell sharply during the 1980s—largely as a result of the declining fortunes of the domestic oil industry—while those of Kentucky, Tennessee, Alabama, and Mississippi remain 20 to 25 percent below national averages. The only region to show continuous growth between 1970 and 1985 is the southeastern coast, stretching from Maryland to Florida.[98]

Figure 5-9.-Convergence and Divergence of Regional Income (per capita personal income as percent of U.S. average)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "Regional Differences in Per Capita Personal Income Widen in the 1980s," news release No. BEA 87-39, Washington, DC, Aug. 20, 1987.

In citing these figures, of course, it should be noted that personal income as an indicator of economic vitality can be misleading when separated from other indicators. Costs of living can vary according to region, and regional aggregations mask important movements on a local level.[99] Nonetheless, the trends revealed in figures 5-8 and 5-9 are reinforced by trends in earnings (compensation paid to employees) over the past decade. Earnings in the far west remain far above the national average, while States along the Atlantic coast have enjoyed rising relative earnings.[100] Indeed, the one-third of all 50 States located along both coasts have generated roughly three-quarters of real U.S. growth in wages and partnership income during the 1980s.[101]

Explaining the Change

The changes now underway in the geography of U.S. economic activity are being driven by several forces:

- Information and transportation technologies—ranging from nationwide computer networks to inexpensive, fast air freight services—allow easier movement of the goods and information flows needed for efficient management of activities in diverse areas.

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[98] U.S. Department of Commerce, Bureau of Economic Analysis, "Regional Economic Information System," tables SA1, SA2, SA3, Washington, DC, unpublished.

[99] Linda LeGrande and Mark Jickling, "Earnings as a Measure of Regional Economic Performance," U.S. Congressional Research Service, Report No. 87-377E, Apr. 27, 1987, p. 2.

[100] Ibid. p. 8. See also Lynn E. Browne, "Too Much of a Good Thing? Higher Wages in New England," *New England Economic Review*, January/February 1987, pp. 33-51.

[101] Daniel Bell, "The World and the United States in 2013," *Daedalus*, vol. 16, No. 3, summer 1987, p. 20.

- The growing contribution of transactional service industries, where many activities do not require physical proximity to clients or raw materials, permits a mobility not available in heavy manufacturing.
- Within manufacturing, growth has been largely in goods with a high value per unit weight, particularly the products of many of the newer enterprises located in the northeast.[102] Such firms can transfer production facilities more rapidly than those involved in traditional "heavy" manufacturing, which still provide a comparatively large share of the economic base in midwestern States.
- Declines in natural resource inputs throughout the economy increase the comparative importance of market access, transportation networks, economic base, labor quality and cost, tax environment, and even climate and "quality of life" in the selection of location.
- Air-conditioning and enlightened governance in the sun belt (improving schools, roads, and other infrastructure) have made the region increasingly attractive for retirement, recreation, and enterprise location. The population shifts that ensued have carried a second wave of economic activity with them.
- Geographic movement can also be strongly affected by Federal, regional, and State policies. Subsidized transportation and water helped accelerate development in many regions. State efforts to attract industry through attractive tax or regulatory programs can also play a role.

While they once concentrated on efforts to attract manufacturing enterprises, States are now competing for transactional service businesses that may be comparatively footloose. Citicorp, for example, agreed to build a back office facility in Hagerstown, Maryland in order to earn the right to enter the Washington/Baltimore market. Delaware offers attractive locations for data processing and credit card centers; Marine Midland and Morgan Guaranty have established computer centers in that State.[103]

Many States are also attempting to establish environments conducive to high-technology enterprises, attracting private firms with promises of additional public assistance; 35 such State efforts were operating in 1985, compared to 4 in 1979.[104] A recent program in Pennsylvania involving public allocation of $26.4 million over a 3-year period is credited with encouraging 500 business startups and expansions in that State.[105]

When all factors are accounted for, however, it appears that a region capable of providing well educated people has an advantage that is difficult to overcome through other incentives.

Southern and western metropolitan areas attracted many new firms, expansions, and regional transplants during the post-war era. The west continues to grow, while the southwest has suffered somewhat due to changing conditions in the oil industry. An improved interstate highway system, the maturing of the U.S. trucking industry, and innovations in air transportation provided new forms of access to regions with lower labor costs, playing a major role in attracting business to the south and west.[106]

Rapid business growth in these regions created jobs that were filled quickly—even in tight labor markets—as workers from depressed areas took advantage of faster and cheaper means of transportation in order to arrive at areas with employment opportunities. Population growth followed. This, in turn, was followed by yet more employment growth. To support the larger numbers of enterprises and workers—as well as the influx of retirees to the southern regions, who were now able to move to warm climates without breaking ties to their former places of residence—demand for service industries rose dramatically.[107] Of course, services were also a significant part of the initial movement away from the industrial north, due to the ability of service enterprises to transfer operations with comparative ease.[108]

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[102] See Daniel Bell, op. cit., footnote 101; and Benjamin Chinitz, "The Regional Transformation of the American Economy," paper delivered to the American Economic Association, May 1986.

[103] M. Moss and A. Danau, "Will the Cities Lose Their Back Offices?" *Real Estate Review*, vol. 17, No. 1, spring 1987.

[104] Edward J. Malecki, "Hope or Hyperbole? High Tech and Economic Development," *Technology Review*, vol. 90, No. 7, October 1987, p. 45.

[105] W. John Moore, "High-Tech Hopes," *National Journal*, vol. 18, No. 46, Nov. 15, 1986, pp. 2769-2773.

[106] Mark Perlman, *Patterns of Regional Economic Decline and Growth* (Washington, DC: American Enterprise Institute, 1982). For more on this subject, see R.D. Norton and J. Rees, "The Product Cycle and the Spatial Decentralization of American Manufacturing," *Regional Studies*, vol. 13, 1979, pp. 141-151.

[107] See Lynn E. Browne, op. cit., footnote 100; and Richard J. Rosen, "Regional Variations in Employment and Unemployment During 1970-82," *Monthly Labor Review*, vol. 107, No. 2, February 1984, pp. 34-35.

The pattern of decline that characterized many northeastern cities during the 1970s has been slowed and in some cases reversed, buoyed by sharp growth in transactional service employment and "high technology" (largely medium-wage) manufacturing. The northeast, and the middle Atlantic States to a lesser extent, now enjoy economic growth rates as good or better than the U.S. average. In some cities, this has been reflected through recent population gains; as table 5-9 shows, the Philadelphia area grew by 57,000 people and the New York City area grew by 50,000 between 1985 and 1986, while the Washington, DC area continues to rank among the Nation's population growth leaders. On the other hand, job growth in much of New England has been greater than the rise in population.[109]

More than three-quarters of new jobs result not from moves, but from startups or expansions.[110] New England enjoyed rapid rates of growth of new business and comparatively low rates of business failures during the 1980s.[111] For many companies, the theoretical advantages of moving a facility to a low-wage region appears to have been offset by the advantages of a good educational system and other critical infrastructure. New England's stubborn maintenance of high-tax and extensive business regulation proved less of a barrier, given highly rated State and local educational systems and other infrastructures purchased from these taxes[112]—as well as highly respected private educational institutions enjoying indirect public support through tax exemptions.

Ironically, the comparative resurgence of northeastern States over the past decade may have been spurred in part by the recessions of the early 1980s.[113] New England, which had been in relative decline prior to that time, was affected less severely than other regions. Moreover, these recessions brought real interest rates to historically high levels, leading to a sharp increase in the cost of housing in the south and west—regions which depended heavily on new construction and suffered from spiraling land costs.[114]

Companies making high-technology products, contacted in a 1982 survey, did not feel particularly constrained by access to raw materials, energy, or climate—none of which are at a premium in the northeast—in selecting a site (see table 5-10). Access to raw materials was consistently at the bottom of the priority list, with only 27.5 percent of the respondents saying that such access was "significant or very significant" in their choice of a site. Instead, companies tended to choose locations on the basis of skills, labor costs, tax climate, costs of living, and several categories—academic institutions, transportation, and access to markets—generally associated with metropolitan areas.[115]

High-technology firms can generally move with comparative freedom from one region to another. Given the greater relative growth of the U.S. east and west coasts during the 1980s, this has led to a preponderance of high-technology activity around urban centers in these regions. Such a trend is reinforced by recent patterns of concentration among U.S. research and development (R&D) facilities, which tend to require higher levels of capital investment than do high-technology manufacturing enterprises.[116] Ranking the number of leading R&D centers by metropolitan area in 1987, one study has found that only one of the top eight (Chicago, ranked fifth) was not located on or near either coast.[117] The same study concludes that "the prominence of the California and East Coast core areas in R&D facilities was even more pronounced in terms of high-tech and microcomputer firms."[118]

While job-related moves have not been the only reason for these regional shifts, table 5-11 suggests that nearly half of all interregional moves are job-

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[108] R.D. Norton, op. cit., footnote 3.

[109] This has led to some concern that New England's economy may soon be constricted by a shortage in the supply of labor. See "New England Warned of a Labor Shortage," *The New York Times*, sec. 1, Dec. 2, 1987; and Lynn E. Browne, op. cit., footnote 100.

[110] *Development Report Card for the States* (Washington, DC: Corporation for Economic Development, March 1987).

[111] *The State of Small Business*, op. cit., footnote 44, 1984, pp. 16-17, 20-21.

[112] *Development Report Card for the States*, op. cit., footnote 110.

[113] Mark Perlman, op. cit., footnote 106.

[114] Ibid., p. 302.

[115] U.S. Congress, Joint Economic Committee, "Location of High Technology Firms and Regional Economic Development," Washington, DC, 1982.

[116] Edward J. Malecki, op. cit., footnote 104, p. 46.

[117] Michael O'Connor, "Many Prominent R&D Centers Favored by Facility Planners Continue 25-Year Dominance," *Site Selection Handbook*, vol 32, No. 3, June 1987, pp. 564-572.

[118] Ibid.

Table 5-10.—Factors that Influence Location Decisions of High-Technology Companies (percent responding that the factor was "significant" or "very significant")

Choices among different regions	Percent
1. Labor skills/availability	89.3
2. Labor costs	72.2
3. Tax climate in the region	67.2
4. Academic institutions	58.7
5. Cost of living	58.5
6. Transportation	58.4
7. Access to markets	58.1
8. Regional regulatory practices	49.0
9. Energy costs/availability	41.4
10. Cultural amenities	36.8
11. Climate	35.8
12. Access to raw materials	27.6

NOTE: High-technology industries were taken from the following Standard Industrial Classifications: drugs, ordinance and machine, electrical and electronic machinery, equipment parts, miscellaneous transportation equipment, and measuring, analyzing and controlling instrument, photographic, medical, and optical goods, watches and clocks. Most respondents were semiconductor or telecommunication firms located in Massachusetts and California.

SOURCE: U.S. Congress, Joint Economic Committee "Location of High Technology Firms and Regional Economic Development," Washington, DC, 1982.

related; 60 percent are either directly job-related or are associated with retirement, the armed services, or education.[119] Within this overall structure, priorities for moving differ widely according to age. Younger people tend to move to attend school or look for work more than other age groups; middle-age Americans move as a result of job transfer more than their younger and older counterparts; and the vast majority of older people relocate for retirement, climate, or family considerations. It is interesting to note that this pattern may change somewhat as the baby-boom generation moves through middle age. Since two-earner families are more likely to be found among baby-boom households, more two-earner families will move into middle age. Two-earner families are less likely to relocate for employment reasons than other household types,[120] suggesting that the rate of job-related movement among middle-age Americans may decline over the next several decades.

The Move to the Urban Fringes

Defining the Change

A move of population and employment from central cities to nearby suburbs has been underway for many years. Increasing incomes have allowed Americans to escape the congestion and high cost of urban centers and to search for the amenities of suburban living, while remaining close to the cultural and economic opportunities associated with cities. In the northeast and west, much suburban growth has occurred in small areas adjacent to large metropolitan centers, while exurban growth in the south and north central regions has occurred near small and intermediate-sized metropolitan areas.[121]

In the 1960s, all regions exhibited more rapid metropolitan growth than non-metropolitan growth (see table 5-12), and much of the non-metropolitan movement came from population increases in counties adjacent to metropolitan areas. The differences narrowed during the 1970s, although non-adjacent counties still grew less rapidly than adjacent ones. Nonetheless, non-adjacent counties were growing more rapidly than urbanized counties for the first time, in all regions except the south. Indeed, the 1970s saw non-adjacent rural areas of less than 2,500 people grow by 14.6 percent, after such areas had decreased in population by 4.2 percent during the 1960s.

On a regional basis, these smallest-sized areas grew more rapidly than did larger non-adjacent counties in the northeast, south, and west. Such a remarkable change in population growth suggested further non-metropolitan population deconcentration, representing a break with past trends.[122]

While the population of all central cities grew by only 0.1 percent during the 1970s, central cities in SMSAs (standard metropolitan statistical areas) with populations of less than half a million grew 10.6 percent. Central cities in SMSAs with a population of more than 1 million declined by 4.2 percent or more.[123]

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[119] Larry H. Long, *Migration and Residential Mobility in the United States* (New York, NY: The Russell Sage Foundation, 1988).

[120] "Job Seekers Stay Put," *The New York Times*, p. D1, Oct. 4, 1987.

[121] Larry Long and Diana DeAre, "The Economic Base of Recent Population Growth in Nonmetropolitan Settings," U.S. Department of Commerce, Bureau of the Census, Washington, DC, 1982.

[122] D.R. Vining, Jr. and A. Strauss, "A Demonstration That the Current Deconcentration of Population in the United States is a Clean Break With the Past," *Environment and Planning A*, vol. 9, 1977, p. 751.

[123] John F. Long, "Population Deconcentration in the United States," U.S. Department of Commerce, Bureau of the Census, Washington, DC, 1981.

Table 5-11.—Reasons for Inter-Regional Moving, 1979-1981 (in percent, by age of household reference person)

	Age of reference person:											
	All ages	Under 25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70+
Job transfer	22.2%	14.8%	25.0%	28.4%	32.6%	30.2%	24.7%	23.7%	15.4%	9.7%	0.0%	0.0%
Look for work	6.3	9.7	5.9	5.6	6.7	4.4	5.0	6.2	6.6	1.5	0.0	2.9
Take new job	18.7	21.8	21.7	21.6	19.3	18.7	19.1	16.0	9.0	6.5	0.5	0.8
Armed Forces	3.4	6.9	5.2	2.5	0.8	3.5	1.1	0.0	0.0	0.0	0.0	0.0
Retirement	2.4	0.0	0.0	0.1	1.4	2.9	3.8	2.8	10.7	23.3	14.9	6.2
Attend school	5.6	15.4	6.9	2.9	2.4	0.0	0.6	0.0	0.7	0.0	0.0	0.0
Closer to relatives	8.6	4.2	6.9	7.2	6.0	5.7	8.6	12.8	13.7	14.9	21.5	44.7
Change climate	6.0	2.9	4.7	3.2	5.3	4.6	3.6	13.2	15.0	14.1	30.2	13.4
All other	26.8	24.4	23.8	28.5	25.5	30.0	33.5	25.3	29.0	30.0	32.8	32.0
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total (000's)	6,250	1,362	1,352	988	694	471	338	252	235	203	143	211

NOTE: Total percent may not add to 100 due to rounding.

SOURCE: Larry H. Long, *Migration and Residential Mobility in the United States* (New York, NY: The Russell Sage Foundation, 1988), table 7-2.

Table 5-12.—Population Growth by Region by Metropolitan and Non-Metropolitan Counties (1960-70 and 1970-80, in percent)

County population change	Total	Northeast	North-central	South	West
1960-70:					
Total	**13.4%**	**9.8%**	**9.6%**	**14.3%**	**24.2%**
Metropolitan	17.1	10.0	13.1	22.2	28.4
Non-metropolitan					
Total	3.9	8.4	2.0	2.6	9.0
Adjacent to metro area	6.2	10.0	4.4	4.3	13.3
Not adjacent to metro area	1.0	3.5	−0.9	0.8	5.0
1970-80:					
Total	**11.4**	**0.2**	**4.0**	**20.0**	**23.9**
Metropolitan	10.0	−1.8	2.6	21.5	22.1
Non-metropolitan					
Total	15.4	12.8	7.4	17.3	31.6
Adjacent to metro area	16.7	13.1	8.6	19.6	34.4
Not adjacent to metro area	13.8	11.8	6.0	14.7	28.8

NOTE: SMSA/NECMA boundaries as of January 1, 1980.

SOURCE: Larry Long and Diana DeAre, "The Economic Base of Recent Population Growth in Nonmetropolitan Settings," U.S. Bureau of the Census, 1982.

The trend toward suburbanization among U.S. metropolitan areas as a whole slowed between 1980 and 1984, while central cores actually gained population share.[124] Nonetheless, it still appears that urban fringe areas are alive and well, expanding in every region of the country—from Tyson's Corner, Virginia to the South Coast Metro Center in Orange County, California.[125]

Jobs have followed the population to the suburbs and smaller cities. Between 1967 and 1977, suburban employment growth accounted for 81.7 percent of all job growth in the 50 largest SMSAs, while central city shares of total metropolitan employment in the 50 largest SMSAs fell from 63.6 to 53.4 percent.[126] Total central city employment grew 7 percent over this period, while suburban employment grew 59.2 percent. And between 1970 and 1980, the most pronounced declines in the number of people commuting from homes in central cities were found in the 25 largest cities (see table 5-13).

In smaller SMSAs, though most suburban growth rates again exceeded those of central cities, average growth rates were less divergent. Central city employment for 50 selected small and midsized SMSAs increased by 23.7 percent between 1967 and 1977, as opposed to the 7 percent growth of the 50 largest SMSAs.[127] Moreover, between 1970 and 1980 there was a sharp increase in the number of people living in suburbs of major cities and commuting to jobs outside the city center. (Again, see table 5-13; for more on this subject, see discussion of transportation in ch. 3.)

Metropolitan areas gained much of their job growth between 1975 and 1979 as a result of increases in service employment (see table 5-14). The dependency on services was even more pronounced in the largest metropolitan areas. For those with 3 million or more in population, services accounted for 41 percent of all jobs generated between 1975 and 1979. While Citicorp moved some of its back office functions to the Dakotas, this appears to be an exception rather than a rule. Of the top nine banks contacted in a regional survey, seven had located operations for high-volume check processing and credit card operations in suburban or satellite cities but most were within 60 miles of a city center.[128]

Securities firms originally concentrated in downtown Manhattan because of the need to physically

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[124] Charles L. Leven, "Post-Industrialism, Regional Change and the New Economic Geography," paper prepared for the Conference on America's New Economic Geography, Washington, DC, Apr. 29-30, 1987.

[125] William K. Stevens, "Defining the 'Outer City': For Now, Call It a Hybrid," *The New York Times*, sec. 1, Oct. 12, 1987, reporting a conference of the Urban Land Institute.

[126] Robyn S. Phillips and Avis C. Vidal, "The Growth and Restructuring of Metropolitan Economies," *Journal of the American Family Planning Association*, summer 1983, p. 295.

[127] Ibid.

[128] M. Moss and A. Danau, op. cit., footnote 103.

Table 5-13.—Changes in the Location of U.S. Jobs and Homes

	Workers living in the largest 25 urbanized areas		Workers living in other urban areas	
	1970	1980	1970	1980
Living in a central city and working in:				
—CBD^a	6.6%	4.7%	5.6%	6.5%
—Non-CBD portion of central city	30.0	24.7	45.9	40.1
—Outside of a central city	8.9	6.8	12.9	10.7
Living in the suburbs and working in:				
—CBD	3.2	3.7	1.7	2.8
—Non-CBD portion of central city	13.1	14.3	13.4	16.4
—Outside of a central city	30.0	45.7	20.4	23.4
Total (percent)	100.0	100.0	100.0	100.0
Total (millions)	25.5	30.7	17.0	25.3

[a] CBD = Central Business District.

SOURCE: U.S. Department of Energy, Urban Mass Transportation Administration, *Demographic Change and Recent Worktrip Travel Trends* (UMTA-DC-09-7009), Washington, DC, February, 1985.

deliver certificates. Although only one of the Nation's top 10 securities firms has back offices and headquarters in same buildings, and only 2 have data processing in their corporate headquarters complex, most of these firms are not moving out of the New York metropolitan area.[129] Rather, they are moving to New Jersey or other close sites in New York metropolitan area—Morgan Stanley moving to Brooklyn, or Paine Webber to Weehauken, New Jersey. Dean Witter was an exception, moving to Dallas.

Significant differences exist in geographic employment shifts within industries (again see table 5-14). Much of the decentralization of manufacturing, such as IBM to rural Vermont, has resulted from decentralized management (described earlier in this chapter). Branch plants are often located in suburban areas distant from a company's main plants or headquarters; one study found that most branch plants were spawned from corporate headquarters in the manufacturing belt, even in the southwest.[130] Thus, part of non-metropolitan industrial growth seems to occur with the decentralization of production processes into peripheral areas of the manufacturing belt.[131] Similarly, data-processing and client-aid services, which can be transferred from central offices in order to save on labor and real estate costs, can move easily because of advanced telecommunications networks.[132]

Explaining the Change

At the turn of the century, elevators, telephones, indoor plumbing, and other technologies made highrise office buildings and apartments possible, thereby opening possibilities for highly concentrated urban centers. The national highway system, built during the 1950s, literally paved the way to suburban development, just as railroads had opened the West to development two generations earlier. In each case, regulations and public action played a major role. Western development was a conscious act of public policy encouraged by subsidies to transportation systems, free land, rural electrification, and a variety of other programs. Suburban development was shaped by highway policy and zoning. Undoubtedly, the desire to escape the problems of urban centers also played a major role.

One of the features of the emerging U.S. economy is that the rules governing the shape of American cities and towns may be changing. An economy increasingly dependent on transactional services, and a manufacturing system where rapid growth can occur in relatively small facilities or facilities with relatively modest freight requirements, allows greater flexibility in locating businesses close to areas where employees can find attractive housing, schools, and recreational facilities. (Again, see ch. 3 for a discussion of changing patterns of transportation between work and living.)

Relocation along these patterns, however, may be contributing to a dilemma of major proportions (discussed further in ch. 11). Suburban movement can

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[129] Ibid.

[130] Rodney A. Erickson and Thomas R. Leinbach. "Characteristics of Branch Plants Attracted to Nonmetropolitan Areas," *Nonmetropolitan Industrialization*, R.E. Lonsdale and H.L. Seyler (eds.) (Washington, DC: V.H. Winston & Sons, 1979).

[131] R.D. Norton and J. Rees, op. cit., footnote 106.

[132] M. Moss and A. Danau, op. cit., footnote 103.

Table 5-14.—Change in Employment for Metropolitan and Non-Metropolitan Counties and Types of Non-Metropolitan Settings, 1975-79 (in percent, by major industry group)

Industry	Metro	Non-metro	Non-adjacent	Adjacent
Agriculture, forestry, and fisheries	45.7	28.1	35.9	18.5
Mining	21.8	13.5	14.0	13.1
Contract construction	34.8	44.2	48.1	40.1
Manufacturing	15.8	20.7	20.1	21.5
Transportation and public utilities	14.5	30.9	31.2	30.5
Wholesale trade	19.4	21.4	21.0	21.8
Retail trade	22.2	26.6	26.7	26.6
Finance, insurance, and real estate	20.0	29.6	31.0	28.0
Services	32.9	32.6	33.2	31.9
Total employment	22.5	25.2	25.8	25.6

NOTES: SMSA/NEGMA boundaries as of January 1, 1980; employment data from *County Business Patterns;* non-adjacent means not adjacent to SMSA; adjacent means adjacent to SMSA.

SOURCE: Larry Long and Diana DeAre, "The Economic Base of Recent Population Growth in Nonmetropolitan Settings," U.S. Bureau of the Census, 1982.

leave behind the significant share of a region's population living in central cities, where attaining a job often requires the mobility provided by a car due to the limited nature of public transportation from cities to suburbs. Moreover, in the sense that the new employment opportunities within coastal cities are largely related to transactional services, and require higher levels of education than traditional manufacturing jobs, the comparatively low educational standing of inner-city residents—many of whom are minorities—may preclude them from these positions.[133]

Nonetheless, much suburban activity continues to be tied to the cultural and economic opportunities afforded by cities. And it appears that a significant amount of the movement away from urban centers has resulted from the increased merger activity discussed earlier in this chapter. Following the opportunities for growth in suburban and exurban areas, many firms have not only expanded the scale of their operations and the scope of their products—they have branched out physically as well.[134]

Recent patterns of suburban investment may arise from a variety of other factors:[135]

- the availability of low-cost labor;
- employers' perceptions that worker productivity and dependability are greater outside urban areas;
- lower unionization levels, and a perception that workers are less likely to unionize;
- non-economic reasons, such as the simple desire to relocate, that are often given as preferences for less urbanized areas; and
- policy decisions—rural areas enjoy a variety of subsidies relative to more densely populated regions, as highways, telephone service, electric service, police, fire, and other services in rural areas are often heavily subsidized; prices would rise sharply if low-density areas were forced to pay the real marginal costs of these services.

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[133] William J. Wilson, *The Truly Disadvantaged: The Inner City, the Underclass, and Public Policy* (Chicago, IL: University of Chicago Press, 1987). See also Truman A. Hartshorn and Peter O. Muller, "Suburban Business Centers: Employment Implications," U.S. Department of Commerce, Economic Development Administration, Washington, DC, 1987.

[134] Milford B. Green, "Corporate-Merger-Defined Core-Periphery Relations for the United States," *Growth and Change*, vol. 18, summer 1987, pp. 12-35.

[135] Some of these factors are discussed in LSteven R. Kale and Richard E. Lonsdale, "Factors Encouraging and Discouraging Plant Location in Nonmetropolitan Areas," *Nonmetroplitan Industrialization*, op. cit. 130.

Chapter 6

The Networks That Produce Amenity

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Chapter 6

The Networks That Produce Amenity

The previous two chapters described broad patterns of change in the national economy. While there are themes common to all business networks, each is changing in unique ways. A close examination of each network is needed to understand many of the changes taking place. These examinations provide a basis for hypotheses about the future that could not be constructed by extrapolation. They also offer a different perspective on the practical choices facing public policy makers. In some cases, the discussions reveal the need for reforms that apply only to specific business sectors. In others, they show how programs designed to facilitate national economic growth will help or hinder productive restructuring in a given sector.

The sector discussions in this chapter test national themes to see how they apply in practical cases. Each addresses the following questions:

- How does the network operate as an integrated system, combining goods and services to connect primary resources to final markets?
- How are the roles of the different component businesses within the network changing? How are the connections between them changing the performance of the whole?
- How does the scale and scope of enterprises within the network affect the production process?
- What is the significance of new developments in the geographic location of production facilities?
- What is the relative importance of technology, trade, regulation, and other forces shaping change in the networks?
- What shape may these networks take in the future?
- What practical choices affect the direction the networks take?

Each discussion represents, in effect, one column of table 4-6 in chapter 4. Organization of the chapter by amenity group maintains a clear view of the integrated performance of networks.

Examinations of specific business sectors comprising the larger amenity network appear as follows:

- Most amenity networks make heavy use of inputs from one production sector. An analysis of the current and possible future performance of such business sectors therefore appears in the section covering the related amenity group. The discussions of Health and Education, for example, cover many issues relevant to the Social Service sector. Transactional Activities are treated in the discussion of Personal Business and Communication.
- Where appropriate, the amenity discussions also contain a review of intermediate demand for the products of the primary business sectors analyzed.
- While manufacturing issues appear throughout the amenity discussions (e.g., the manufacture of textiles and apparel is discussed in the Clothing and Personal Care section, and food manufacturing in Food), a final section pulls the pieces together and provides an overview of changes in manufacturing.

FOOD[1]

Prospects

Most farm products are produced by businesses managed more like manufacturing facilities than the farm operations of an earlier generation. A growing fraction of all American spending on the Food amenity goes to add value after food products leave farming operations. This value comes in the form of increased variety in fresh foods as well as varying degrees of processing. Processing alternatives now include such things as tablecloth restaurants, fast food, and a range of frozen and fresh entrees in grocery stores.

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[1] Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Food," sector study, Washington, DC, 1987.

The American food production and distribution system has been reshaped by changing consumer incomes and expectations (see ch. 2). Parts of the industry never before exposed to foreign competition find themselves struggling to maintain market share. Imports of processed foods (such as confections, alcoholic beverages, and processed foods with an ethnic appeal) have grown so rapidly that they now approximately equal U.S. food exports (which depend almost entirely on bulk commodities and products like meat and meals that require little processing—see ch. 9). Imports of food processing equipment and food processing licenses have also grown.

Technology has had an uneven effect on the businesses that comprise the food network. Farm productivity and the productivity of many food manufacturing activities has grown rapidly, while productivity growth in wholesale and retail enterprises has been sluggish. Technologies likely to have the most profound effect on the operation of the American Food system may not appear as measured productivity gains in any component business (as will be the case with the provision of Clothing and Personal Care). Information technology can tie retail, wholesale, transportation, food processing, and farm operations together in ways that facilitate system-wide flexibility and productivity. New packaging and preservation techniques can improve the quality of products reaching consumers and can reshape the structure of the businesses moving farm products to forks.

Several different outcomes are possible during the next 20 years:

- The food production system could grow in a way that would make it a tightly integrated, high-technology production network. Improved management systems can be implemented through information technology and lowered costs made possible by new, safe packaging and preservation technologies, which allow a greater variety of fresh products to be available at comparatively low costs. Foods can be tailored to regional or ethnic tastes, for special dietary needs (e.g., low-sodium or low calorie) and for other specialized markets (e.g., elderly individuals looking for a high-quality menu that can be prepared at home with little effort)—all without a significant increase in cost. Competition on the basis of quality could increase consumer knowledge of the health implications of their diets.
- The flexibility of the new communication system could allow a variety of comparatively small producers of farm products and small manufactured food processors to enter networks once reserved for very large firms. Improved on-farm technology, coupled with improved packaging, communication, and transportation networks, could lead to increased productivity in specialized food products like cultivated fish and many varieties of fruits and vegetables.
- Capital equipment could replace many clerical and low-skill tasks in retail, and wholesale operations could be automated. With the possible exception of meat processing, the productivity of food processing facilities could increase to the point where dangerous and low paid occupations would be largely replaced by machinery.
- Lack of effective competition could decrease product quality and the potential of new efficiencies may not rebound to the advantage of consumers. Foreign products could provide much of the variety available on store shelves. Large oligopolies, investing little in research or new equipment, could compete largely on the basis of advertising rather than product quality. Low-income and rural areas could find themselves facing a sharp decline in real choice and an increase in real food prices. Productivity and food preservation could be achieved by methods with adverse health effects. Oligopolies in food services could replace regional and ethnic diversity with homogeneous national products.
- Small farms could be reduced to little more than hobbies with virtually all food value produced on very large farms (many of which may be owned by a single family). The "post-harvest" businesses could be divided between sophisticated manufacturing enterprises on the one hand, and meat-packing, wholesale, grocery, and restaurant operations—which show virtually no productivity gains and provide large numbers of poorly paid jobs—on the other.

These alternatives are obviously not mutually exclusive. Signs of each can be found in existing trends.

The role of government in the Food network varies greatly from sector to sector. The farming industry is heavily influenced by government programs—through both heavy Federal funding of research and massive price support programs. Federal farm programs totaled $60 billion between 1981 and 1986.[2] Federal regulations provide extensive if uneven coverage of food-product safety.

Structure and Performance

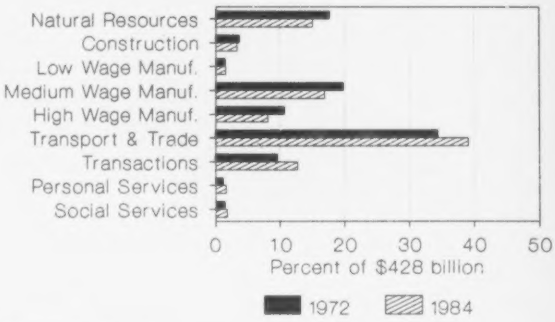
The system that brings food to American forks provides business throughout the U.S. economy. Of the approximately $427 billion of value-added in the economy generated directly and indirectly by Food consumption in 1984, nearly 40 percent ended up in the transportation and wholesaling industry, grocery stores, and restaurants. Approximately 15 percent resulted from farm and other resource inputs. Food manufacturing contributed approximately 17 percent of value-added. During the past decade, farming, other natural resource inputs, and manufacturing have lost their share of the American food dollar (measured in constant dollars), while transportation, trade, and transactional enterprises have gained (see figure 6-1).

The Farm Sector

Technology and Productivity.—Enormous productivity gains in farming were among the most obvious symbols of economic transformation at the turn of the century. During the past 60 years, the U.S. agricultural sector has undergone two technological revolutions—the mechanization of farming, and the widespread use of chemical inputs. Less than 3 percent of the U.S. work force feeds the U.S. population and provides a large surplus for export. A century ago, the majority of American workers were employed on farms.

The system is far from running out of ideas. Rates of productivity growth are expected to be rapid for the next two decades.[3] Agriculture is probably on the verge of a third technological revolution, stemming from advances in biotechnology, information-processing technology, and a variety of other innovations.

Figure 6-1.-Value-Added To Meet Demand for Food ($428 billion* in 1984)



*Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

A study analyzing the potential impacts of 150 emerging technologies on future agricultural production predicts strong productivity growth throughout the next two decades.[4] In the near term, the largest increases are forecast for the dairy sector, with milk productivity projected to increase at an annual rate of 3.9 percent—compared with 2.6 percent over the past two decades. The application of biotechnology to crop production is expected to proceed more slowly, with widespread adoption forecast after the year 2000.

Scale and Scope.—It is not surprising that enormous growth in farm productivity led to massive structural changes in American farming. The new production systems changed activities on the farm, requiring sophisticated management practices, new technical expertise, and heavy investment in capital equipment. They have also reshaped the economics of large and small farming operations. The question of whether new agricultural technologies have selectively benefited large or small farms is a matter of dispute and recent litigation.[5]

What cannot be disputed is that the number of farms in the United States has decreased by nearly two-thirds since the pre-World War II peak of 6.5 million. Of the 2.3 million farms that remained in 1985, 5 percent—about 100,000 farms—accounted for half of the Nation's agricultural production, up from 42 percent in 1960. In terms of net farm income, the largest farms—those with annual gross revenues of more than $500,000, or 1.2 percent of all farms—claimed two-thirds of total income in 1982. In contrast, farms with annual revenues of less than $99,000, which constituted 86.5 percent of all farms in 1982, accounted for less than 2 percent of net farm income. Moderate-sized farms—those with annual sales of between $100,000 and $199,000, and perhaps the closest match to the traditional notion of the "family farm"—represented 8.1 percent of all farms in 1982, and claimed a 14.6 percent share of net farm income.

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[2] *Economic Report of the President, 1987* (Washington, DC: U.S. Government Printing Office, 1987), p. 154.

[3] U.S. Congress, Office of Technology Assessment, *Technology, Public Policy, and the Changing Structure of American Agriculture*, OTA-F-285 (Washington, DC: U.S. Government Printing Office, March 1986).

[4] Ibid.

[5] Decision of the Superior Court of Alameda County, CA, "California Agrarian Action Project, Inc. et al., v. Regents of the University of California," Nov. 17, 1987.

Consolidation of farm enterprises is expected to continue through the remainder of the century. By the year 2000, small and part-time farms with annual sales less than $100,000 are likely to represent 80 percent of all U.S. farms but may earn only 4 percent of cash receipts. Large-scale farms, on the other hand, with annual sales greater than $250,000—only 14 percent of all farms—may earn 80 to 90 percent of all cash receipts.[6]

Geography.—The geography of farm activity is heavily influenced by public programs. Farm product costs vary widely around the nation. In 1982, for example, wheat grown in the northeast cost $2.26 per bushel to produce, while producers in the northern Plains States had costs as low as $1.25. Small farming operations in some areas were able to produce at lower costs than large farms in others.[7] It is possible for farms in several regions to be profitable because public programs regulate prices. Subsidized irrigation and policies allowing the "mining" of groundwater also have the effect of encouraging farm activity in areas which would otherwise find profitable agriculture difficult.

Food Manufacturing

The food manufacturing sector plays a critical role in the Food system, purchasing 70 percent of U.S. agricultural production and largely determining the mix of products available to consumers. It is also the most concentrated sector in the Food network.

Technology and Productivity.—Labor productivity in the food manufacturing business has grown so rapidly during the past several decades that it has outstripped demand growth. Employment in the industry actually declined between 1950 and 1985.[8] With an appropriate research program in food process engineering, annual productivity increases of 2.5 to 3.5 percent are easily possible in food manufacturing during the next decade.[9]

Innovations in food manufacturing have had the effect of reducing a variety of factor costs in addition to improving labor productivity, and are likely to continue to do so. Table 6-1 summarizes a study that covered a variety of innovations under development in the food manufacturing industries. Most of the innovations resulted in a faster process that made more efficient use of energy and raw materials, and most required more capital equipment. Almost without exception they resulted in both improved quality and lower costs.

The rapid growth in imports of manufactured food products and the poor performance of U.S. exports in this area (see ch. 9) do not result from an imbalance in food processing technology. In fact, the productivity of the U.S. industry is probably higher than that of most U.S. trade competitors—including those in Western Europe.[10]

New technologies are expected to have a major effect on the physical processing of food products and the way the products are packaged. Most result from straightforward advances in production engineering. Bioengineering may result in a curious variety of radically new technologies. Artificial citrus juice, for example, has already been produced in laboratories.[11] Intensive efforts are being made to develop calorie-free cake and ice cream.[12]

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[6] *Technology, Public Policy, and the Changing Structure of American Agriculture*, op. cit., footnote 3

[7] Ibid; and U.S. Congress, Office of Technology Assessment, *A Review of U.S. Competitiveness in Agricultural Trade*, OTA-TM-TET-29 (Washington, DC: U.S. Government Printing Office, October 1986), p. 46.

[8] U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, Table 6.7b.

[9] U.S. Congress, Office of Technology Assessment, *Agricultural Postharvest Technology and Marketing Economics Research—A Technical Memorandum*, OTA-TM-F-21 (Washington, DC: U.S. Government Printing Office, April 1983), p. 47.

[10] Center on Transnational Corporations, *Transnational Corporations in Food and Beverage Processing* (New York: United Nations, 1982), cited in John M. Connor et al., *The Food Manufacturing Industries* (Lexington, MA: D.C. Heath & Co., 1985), pp. 22-23.

[11] J. Flynn, "Want Some O.J.? It's Fresh from the Test Tube," *Business Week*, No. 2973, Nov. 17, 1986, pp. 160-161.

[12] "Will Foods of the Future Be Safe?" *The New York Times*, Nov. 19, 1986, p. C15.

Table 6-1.—The Impact of Innovation in Food Manufacturing
(simple counts of primary and secondary impacts)

Impacts on production inputs	Reduced use of factor	Increased use of factor	
Labor	325	8	
Energy	128	9	
Packaging materials	126	23	
Plant time	238	10	
Transportation	26	0	
Equipment	96	269	
Impacts on product quality	Higher quality	Same quality	Lower quality
Lower price	23	14	2
Same price	26	4	0
Higher price	77	5	2[a]

[a] Both cases occurred in packaged fluid milk production.

SOURCE: John M. Connor, "Market Structure and Technological Opportunities in the U.S. Food Manufacturing Industry," contract report prepared for the Office of Technology Assessment, March 1986.

New packaging and preservation techniques present a major opportunity for savings. Losses of fruits and vegetables during transportation and storage have been estimated to be as high as 30 percent of the total supply.[13] Packaging may also contribute as much as 30 percent of the value-added to processed foods.[14] Packaging costs exceed the cost of food products in beer, soft drinks, breakfast cereals, frozen specialties, canned soups, baby foods, and pet food.[15] Packaging weight and bulk contributes significantly to transportation and warehousing costs. If nothing else, the lack of standardization in packaging results in a situation where transportation, wholesaling, and retailing must handle from 2,500 to 5,000 different container sizes.[16]

A major shift in containers is already underway. Glass and metal containers contain a shrinking fraction of the fruit and vegetables purchased by American shoppers.[17] Plastics and other polymeric materials will continue to displace glass and metal containers. New technology has the potential to increase food quality, prolong shelf-life, and reduce shipping weight and volume. Multi-layer packaging can provide long shelf-life without refrigeration for many products. Aseptic processing and packaging, which involves fast heating and sealing, is now used in fruit juice and is being introduced for wines, fruit purees, dairy products, tomato products, and edible oils. Packaging with precise mixtures of oxygen and carbon dioxide can allow fresh fruit to ripen to, but not beyond, desired levels. A freshness indicator can provide visible warning to merchants and consumers when fish products are not safe.

Irradiation of food to preserve freshness has promise in some areas but has encountered consumer resistance. Economies of scale will be pronounced for relatively small, free-standing irradiation facilities. Low-unit costs, however, can be realized only with fairly high processing levels. Consequently, only large firms may be able to justify investment in irradiation. But jointly owned facilities, centrally located in important agricultural areas, could be an economic option for small- and medium-sized processors.[18]

Many if not most of the innovations that will lead to productivity growth in food manufacturing are unlikely to be developed by the food manufacturing industries themselves. The industry spends only about 0.4 percent of sales on research and development—far lower than the average for all manufacturing. Between 1969 and 1977, 90 percent of patents applicable to the six major food manufacturing industries were granted to government laboratories, educational institutions, individuals, foreign firms, or domestic companies outside food manufacturing.[19] Between 1971 and 1977, only 12 percent of the Putnam awards for innovations that increase efficiency of food processing were given to U.S. food manufacturers; 45 percent of awards were given to small firms. A study of these awards shows clearly that food processing firms use mergers as a substitute for in-house research—one-quarter of the Putnam awards went to firms that were acquired shortly before or after getting the award.[20]

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[13] *Agricultural Postharvest Technology and Marketing Economics Research—A Technical Memorandum*, op. cit., footnote 9, p. 47.

[14] T.W. Downes et al., "The Impact of New Technologies on the Food Packaging and Preservation Industries," contract report prepared for the Office of Technology Assessment, 1985.

[15] John M. Connor et al., op. cit., footnote 10, p. 38.

[16] C.W. Abdulla, "Potential Effects of Standardized Packaging Systems on Grocery Manufacturing and Distribution," contract report prepared for the Office of Technology Assessment, 1985, p. 64.

[17] Canned fruits and vegetables declined from 20 percent of per capita consumption of 1979 to 18 percent in 1984. Canned fruits (not including juice) declined from 13 percent in 1979 to 11 percent in 1984. U.S. Department of Commerce, International Trade Administration, *1986 U.S. Industrial Outlook*, Washington, DC, January 1986.

[18] R.M. Morrison and T. Roberts, *Food Irradiation: New Perspectives on a Controversial Technology*, contract report prepared for the Office of Technology Assessment, December 1985.

Scale and Scope.—The number of food manufacturing firms has been decreasing at an average annual rate of 2.5 percent since 1947. Concentration varies widely. Only 9 makers of chewing gum exist today, but there are nearly 2,000 wholesale bakers.[21] Much of the growth of large firms has been achieved through acquisitions rather than internal expansion. With $14 billion spent on purchasing, 1985 was a boom year for mergers; tobacco companies began to diversify. R.J. Reynolds spent $5 billion to acquire Nabisco. Phillip Morris acquired General Foods for $5.6 billion. Nestle S.A. purchased Carnation for $3 billion. Beatrice purchased Esmark for $2.7 billion in 1984.[22]

The discussion in chapter 5 showed the difficulty of linking firm size to rates of innovation. A careful study of innovation in food processing suggests that innovation increases with firm size until total assets reach $125 million to $150 million, when they begin to decline.[23] Another study indicates that rates of innovation also increase with market concentration levels, until four firms have captured 50 to 60 percent of the market, but decline thereafter.[24]

One concern about concentration in food processing is that firms in food manufacturing invest more heavily in advertising to differentiate products than in research to produce real innovation. Food manufacturers typically spend at least ten times as much on advertising as on research and development.[25] In 1979, firms in food and tobacco manufacturing accounted for 32 percent of spending for advertising, but only 12 percent of manufacturing receipts. The largest four firms accounted for 21 percent of advertising in 1982.[26]

The meatpacking industry deserves special attention, since it has been an exception to many trends in the industry. With the exception of beef, most meat processing has moved out of the retail stores and into specialized processing centers. Meatcutters preparing beef products are the last skilled trade to have a presence in grocery stores. The prospect of moving these jobs to factories would complete a separation between retail and food processing businesses (see box 6-A).

Distribution Sectors

Wholesale and retail trade in food has grown rapidly. Grocery stores and restaurants gained share of retail sales between 1975 and 1985, while most other retail sectors lost share.[27] While some productivity gains have been measured in these businesses, technology plays a comparatively minor direct role. The indirect effects of the information technology entering these businesses, however, may be large.

Wholesalers have moved slowly to use computers to control inventories, monitor shipments, schedule work, plan storage layouts, and dispatch trucks. A variety of technologies, such as automatic handling equipment, have the potential to improve productivity of food wholesale operations by as much as 50 percent.[28] Explanations for the slow rate of adoption vary. Is it lack of competition, inefficient management, or the shortage of trained personnel in wholesale firms capable of managing a transition to new technology? Do the large number of products and container types make automation impractical? The debate cannot be resolved easily.

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[19] W.F. Mueller, J. Culbertson, and B. Peckham, *Market Structure and Technological Performance in the Food Manufacturing Industries*, University of Wisconsin, Monograph 11, NC-117, Madison, WI, 1982.

[20] Ibid.

[21] J.M. Connor et al., "The Organization and Performance of the Food Manufacturing Industries," in B.W. Marion, ed., *The Organization and Performance of the U.S. Food System* (Lexington, MA: D.C. Heath and Co., 1986), p. 211.

[22] *1986 U.S. Industrial Outlook*, op. cit., footnote 17, p. 40-1.

[23] Mueller et al., op. cit., footnote 19.

[24] J.M. Connor et al., *The Food Manufacturing Industries*, op. cit., footnote 10, pp. 322-323.

[25] Ibid., pp. 23, 87-89.

[26] Internal Revenue Service data, cited in J.M. Connor et al., *The Food Manufacturing Industries*, op. cit., footnote 10, p. 81.

[27] *1986 U.S. Industrial Outlook*, op. cit., footnote 17, p. 57-1.

[28] G. Grinnell, and L. Friedman, "Productivity Potential in Dry Grocery Centers," U.S. Department of Agriculture, Economic Research Service, AER 484, Washington, DC, 1982.

Box 6-A.—Boxed Beef

In 1920, the four largest beef packers were vertically integrated and commanded 49 percent of all sales. An anti-trust settlement in 1920 dictated a long process of change. By 1970, the combined share of four largest packers fell to 15.8 percent.[1]

In the 1950s, improvements in refrigeration technology and other changes led to greater centralization of cattle processing in feedlots. Retailers like Safeway began consolidating meat cutting into local processing centers. In 1967, the independent (and non-union) Iowa Beef Packing Co. (now IBP, Inc.) opened a semi-automated slaughtering and processing plant in Dakota City, Nebraska

Boxed beef's share of total beef production from all sources is now probably more than 40 percent. Rapidly expanding fast food chains have provided eager markets for their products. The number of meatcutters and butchers employed in retailing has dropped significantly between 1970 and 1980.[2]

Largely as a result of centralized facilities which allowed more sophisticated equipment, meatcutting productivity nearly tripled between 1950 and 1981, measured in beef and pork packed per worker. Partial automation reduced skills and heavy lifting, although the tasks were made much more specific. Injury rates and turnover remain high, while the industry no longer requires a large pool of skilled butchers and meatcutters.[3]

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[1] J. McCoy, *Livestock and Meat Marketing* (Westport, CT: AVI Publishing, 1979), p. 180.

[2] U.S. Department of Labor, Bureau of Labor Statistics, *Employment Projections for 1995*, Bulletin 2197, Washington, DC, March 1984, p. 48.

[3] S.W. Hiemstra, "Technological and Organizational Changes in the U.S. Beef Packing Industry," contract report prepared for the Office of Technology Assessment, 1984.

Food reaches consumers through two channels: food retailers (primarily grocery stores), and food service businesses (restaurants and institutional food outlets). Concentration is increasing in both sectors. However, some convergence exists between the sectors as the variety and extent of processing offered by grocery "superstores" increases. Many of these stores now offer a variety of prepared salads and entrees ready for eating.

Management changes have played a major role in the food service industries. Fast food had the effect of substituting customer labor for service jobs. Technical improvements led to some productivity gains in restaurants between 1958 and 1976, with the introduction of microwaves, deep-fat friers, and other equipment, but productivity has actually fallen since 1976.[29] In food retailing, advanced electronic cash registers and scanners have improved productivity in check-out, though—as the later discussion will show—productivity changes are difficult to measure in individual stores.

Scale and Scope.—The number of wholesale establishments was trimmed by nearly half between 1950 and 1982, and consolidation shows no sign of abating. The eight largest general wholesalers accounted for 26.5 percent of sales in 1982, as compared with 16.2 percent in 1972. Yet the consolidation of warehouse ownership may actually increase competition if larger, sophisticated firms compete in the same region. A recent U.S. Department of Agriculture study concluded that "there are more local suppliers now than in the mid seventies."[30]

The total number of grocery stores has fallen after peaking in the mid 1970s. While conventional supermarkets still claim the majority of grocery sales (59 percent in 1984), their role is rapidly declining.[31] Superstores, which account for only 3.7 percent of all grocery stores, account for 28 percent of grocery sales.[32] These stores may have 30,000 to 200,000 square feet of sales area and as much as $1 million per week in sales. At the other end of the spectrum, the number of convenience stores, where the average sale is $1 to $3, have tripled between 1963 and 1984, and now account for 12 percent of all grocery sales.[33] Specialty stores like bakeries have steadily lost share. In 1982 they commanded only 6 percent of grocery sales.[34] Smaller grocery stores are owned increasingly by smaller firms rather than national chains.

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[29] R.B. Carnes and H. Bran, "Productivity and New Technology in Eating and Drinking Places," in *A BLS Reader on Productivity*, U.S. Department of Labor, Bureau of Labor Statistics, Bulletin 2171, June 1983, pp. 67-72.

[30] W.B. Epps, "Food Wholesaling," *Food Marketing Review, 1985*, U.S. Department of Agriculture, Economic Research Service, AER 549, Washington, DC, March 1986, p. 21.

[31] P.R. Kaufman, "Food Retailing," *Food Marketing Review, 1985*, U.S. Department of Agriculture, Economic Research Service, AER 549, Washington, DC, March 1986.

[32] *1986 Industrial Outlook*, op. cit., footnote 17, p. 57-7.

[33] Kaufman, op. cit., footnote 31, p. 26.

[34] B.W. Marion, ed., op. cit., footnote 21, p. 295.

The larger stores are located almost exclusively in suburban areas. Urban and rural areas may suffer declining choices. Inner-city residents often pay substantially more for similar items than shoppers in suburban supermarkets. A study in Hartford, Connecticut found that a family of four forced to shop at local stores paid $1,500 more annually than if they had gone to suburban markets.[35] Many inner city residents do not have automobiles and are forced to shop in local stores.

The nature of products provided in new, larger grocery facilities has changed significantly. Many have become multi-purpose retail outlets providing pharmacies, teller machines, and a variety of food specialties as well as standard grocery products. A recent survey found that 75 percent of all supermarkets offer health/natural food and gourmet food. At least one-third have low-calorie selections. There is sharply declining interest in "price brand" generic products, the share of which fell from 17 percent in 1982 to 14.6 percent in 1985.[36]

The new grocery stores may also serve as local meeting places and social centers. Many command customer loyalties if only because the time saved by going to a convenience store outweighs the savings that could be achieved by careful shopping. A recent survey indicated that only 1 in 10 consumers said they would shop at a store other than their principal supermarket to get advertised specials.[37]

Grocery stores also serve as major financial centers. Supermarkets cash one-third of all non-government checks.[38]

Food service is an enormous enterprise in the United States, providing nearly 1 out of 13 U.S. jobs. The activities fall into the categories shown in table 6-2. Approximately 70 percent of sales are commercial, the rest in institutions. Because of demographics, there has been a decline in food served in educational facilities and an increase in food sold through hospitals and long-term care facilities. Fast food is rapidly gaining share.

Table 6-2.—Sales of Meals and Snacks in 1977 and 1982 (percent of all sales in year)

Type of sale	1977	1982
Commercial	69.1	70.6
Restaurants, lunchrooms	30.2	30.7
Fast food	24.9	26.4
Other	14.0	13.5
Institutional	30.9	29.4
Educational institutions & day care	10.3	8.6
Hospitals & care facilities	7.7	8.2
Plants, office buildings	4.4	4.5
Military	2.0	1.7
Vending machines	3.1	2.8
Other	3.4	3.6

SOURCE: Michael Van Dress, U.S. Department of Agriculture, private communication, U.S. Congress, Office of Technology Assessment, "Food," sector study, Washington, DC, 1987.

Table 6-3 shows that there has also been a strong movement toward restaurant chains. If anything, the table understates the power of chains, since many independently owned establishments are franchises. Franchises account for 35 percent of all commercial sales. About two-thirds of these franchises are owned by individuals.[39] As a result, nearly half of the sales shown for "1-unit" firms in table 6-3 may be sales by franchised operations. The gap between annual sales of franchises and annual sales of independent restaurants is growing rapidly.[40]

Table 6-3.—Distribution of Eating Places (sales, in billions of dollars)

Number of units	1963	1967	1972	1977	1982
1[a]	80.4	77.4	65.9	59.5	52.3
2-3	5.8	5.3	6.3	6.8	7.1
4-10	2.9	3.7	4.7	6.1	7.2
2-10	8.7	9.0	11.0	12.9	14.3
11 or more	11.0	13.6	23.2	27.6	33.4
Fast food	14.6	19.0	30.3	37.6	39.4

[a] Includes franchises (see text).

SOURCE: J.J. Putnam, H.R. Linstrom, and M.G. Van Dress, "Food Service," in *Food Marketing Review*, 1985, U.S. Department of Agriculture, Economic Research Service, AER 549, Washington, DC, March 1986, p. 44.

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[35] Hartford Citizen's Research Educational Network, "The Poor Pay More: Food Shopping in Hartford," Hartford, CT, 1984.

[36] *1986 U.S. Industrial Outlook*, op. cit., footnote 17, p 57-7.

[37] Louis Harris and Associates, Inc., "Trends: Consumer Attitudes and the Supermarket," survey conducted for the Food Marketing Institute, Washington DC, 1985.

[38] R.E. O'Neill, "What's New in EFT," *Progressive Grocer*, August 1985, pp. 59-66.

[39] U.S. Department of Commerce, Bureau of Industrial Economics, "Franchising in the Economy 1982-1984," Washington, DC, January 1984.

[40] J.R. Schmelzer, "The Commercial Foodservice Sector: Trends in Growth and Market Structures," Working Paper Series WP-56, Michigan State University, East Lansing, MI, September 1981.

New Technologies and System Integration

A variety of new technologies promise to improve the integrated performance of the American Food network in ways that are difficult to demonstrate by examining productivity in individual business sectors (as with Clothing and Personal Care). The two classes of technologies most likely to affect the integrated performance of the food production and distribution system are new packing and preservation technologies (already discussed), and the use of modern communications and information processing systems.

Computers, optical scanners, and other electronic information technologies are now common, but only recently have firms directed their attention toward uses that could pay system-wide benefits. Food-system firms were among the first to take a cooperative approach toward extending the applications of computers. The most visible product of their efforts is the Uniform Price Code (UPC), the now-ubiquitous bar code that is "read" by point-of-sale scanners and portable scanning guns or wands that record incoming shipments and are used to perform shelf inventories.

Retailers, through their new ability to analyze costs and profits in previously unattainable detail, have benefited most directly from these innovations. But the biggest windfall is the large volume of high-precision data it generates, and this information may serve as the basis for improving the entire food marketing system.

Electronic price scanners using the universal product code were first introduced in 1974. It is likely that half of all grocery items were scanned in 1986.[41] For food retailers, the system promises the following types of advantages:

- direct savings through reduced checkout time (by 40 percent) and error rates;
- an ability to make rapid price changes (some stores are moving to electronic price indicators on shelf);
- improved coupon management (in 1983 customers redeemed 5.6 billion coupons worth $2 billion; an estimated 20 percent of coupons are processed in error[42]);
- reduced error rates in billing and ordering (at $11 to $18 per adjustment, price-related errors on about half of the invoices issued by food manufacturers impose annual costs conservatively estimated to total $100 million[43]); and
- precise identification of the effect of advertising campaigns and changes in store format and product placement.

The systems may eventually make it easier for firms to provide the government with requested information. If customers begin to pay for food with credit cards or direct debit cards, sales can also be linked with demographic and income characteristics with great (some would say Orwellian) precision.

For food manufacturers, many of whom purchase scanning data from supermarkets, the information is used to guide marketing strategies, identify new market niches, and evaluate potential changes in products that will boost sales. And for food wholesalers, some of whom use in-house computers to evaluate the efficiency of their operations, feedback on storage and distribution costs may spawn measures to improve efficiency.

Perhaps most importantly, the systems allow a detailed performance evaluation of the thousands of products on their shelves. These evaluations can provide estimates on the real cost of selling each item, preferred stocking patterns, and even information about which warehouse to use as a supplier. At present, few retailers take advantage of the potential to guide merchandise strategies.[44] A more recent development is the Universal Communication Standard (UCS), with which food marketing firms can substitute computer-to-computer communication ("electronic data interchange") for paper-based exchanges of invoices, purchase orders, and reams of other information generated throughout the system.

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[41] P.R. Kaufman, op. cit., footnote 31, pp. 26-27.

[42] H. Monat, "Misredemption of Coupons: A New Solution," Trim, Inc, Los Angeles, CA, 1984.

[43] Ronald Cotterill, "Effects of Electronic Information Technology on Employment in the Food Manufacturing and Food Distribution Industries," contract report prepared for the Office of Technology Assessment, 1985.

[44] Food Marketing Institute, "Retailer Applications of Scanning Data," 1985, cited in C.E. Morris, "Supermarkets: Super Data," *Food Engineering*, May 1986, p. 120; and Food Marketing Institute, "Statement of Food Marketing Institute before the Bureau of Competition, Federal Trade Commission," Milwaukee, WI, Sept. 11, 1984, cited in B. Marion, ed., op. cit., footnote 21.

Now in the early stages of adoption, the UCS, which is a set of protocols that allow one firm's computer to send information to the computer of another, should streamline distribution and marketing functions. It should also eliminate redundant clerical tasks, and some of the duties of the manufacturer's sales force.

In all, the communication network is estimated to offer annual savings of $196 million to $324 million (1979 dollars), assuming the technology is used by the 10,000 largest firms in the food marketing system. Most of the savings would result from reductions in clerical staffs, inventories, and waste and spoilage. Moreover, the network can accelerate recalls of tainted food items, as firms now have the capability to track items throughout the marketing system and, sometimes, back to the farm.

The impact of the communication network on competition is not clear at present. It is clearly possible that large, sophisticated firms will be able to make more effective use of the analytical power of the equipment because of greater access to national data bases and because they can afford to invest in market analysis. They could also carefully monitor regional price competition and quickly cross-subsidize products to beat smaller competitors. Electronic versions of price fixing are possible.

On the other hand, the networks make it possible for large firms to keep track of larger numbers of products and suppliers. This may make it easier for small producers to sell through large stores.

HEALTH[45]

Prospects

The high cost and complexity of new health care technologies have been largely responsible for the massive reorganization of the Nation's health care network that has occurred since the end of the Second World War. Experiments in management and cost containment have proliferated. During the next two decades, the system operating to provide health care could take any of several different courses. They include:

- *A system where institutional incentives throughout the economy are clearly linked to providing the best possible health outcomes at the lowest cost.* This means a system capable of making an even-handed assessment of investments in different kinds of measures to promote health or prevent illness (including investments in air and water quality and occupational safety, and advice on diet, exercise, and other aspects of lifestyle), and clinical treatment of illness when it occurs.
- *A system where a patient's care is diverse and flexible, and can be integrated in a way that ensures optimum health care.* This involves a mixture of home care, treatment by specialized clinics, and local out-patient services with highly sophisticated medical centers in a way that is sensitive to the needs and desires of individual patients.
- *A system that provides timely and accurate records on the effectiveness of alternative treatment strategies.*
- *A system which attemps to contain increases in health costs resulting from a growing elderly population needing medical care, and a growing array of expensive new medical producures and equipment with increasingly baroque regulations.*
- *A system that provides an enormous range in health care quality depending on the patient's ability to pay, permitting only the most affluent to enjoy real choice about courses of treatment.*

Again, these alternatives are not mutually exclusive. They depend heavily on public decisions.

Structure and Performance

About 1 dollar in 10 in the U.S. economy is spent on the Health amenity, either by individuals or the government. This figure does not include spending aimed at improving health, such as investment in environmental protection or safety, healthy food, or fitness. More than half of all value-added in health care enterprises remains in the hands of the Social Service sector, with the rest being spent on such things as hospital construction, purchases of medical equipment, and supplies from High and Medium Wage Manufacturing firms. Purchased Transactional Activities (such as insurance and legal fees) account for nearly 16 percent of Health costs (see figure 6-2). Within the health care enterprises themselves, however, production recipes are heavily dependent on labor; nearly three-quarters of the value of the output of such firms is derived from value-added, most of which is in the form of employee compensation.

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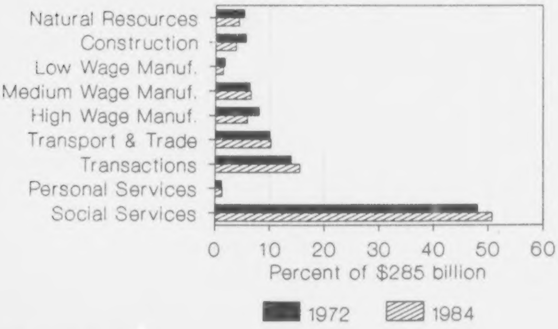
[45] Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Health," sector study, Washington, DC, 1987.

Factors Forcing Change

Until the 1950s, the structure of the Nation's health care system was relatively easy to understand. The system was highly fragmented, highly individualistic, and free of anything but self-regulation by professional societies like the American Medical Association (AMA), which guarded their prerogatives jealously. The courts ruled that anti-trust regulation could not be applied to these organizations since they were "professional societies."[46]

Individual physicians treated most patients in a private practice and resorted to relatively small community hospitals (nearly always operated as not-for-profit organizations) for difficult surgery and some specialized assistance. In extreme cases, they might have turned to a larger hospital in a major urban center. The range of treatment was limited; the family physician played a central role. Most people paid for health care in cash. In 1950, two-thirds of the bill was paid directly by the recipient of the service.

Figure 6-2.-Value-Added To Meet Demand for Health ($285 billion* in 1984)



*Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

Explosive growth in the scope and cost of medical services occurred following World War II, and a complex tangle of programs was put in place to regulate them. Rapidly advancing medical technology opened a wide range of therapeutic options with proven value. The high cost of these opportunities required new approaches to financing. The Hill-Burton program initiated in 1946 encouraged hospital construction. Health care for the needy and the elderly was greatly expanded under the Medicare and Medicaid Acts of 1965 (although gaping holes remain in the coverage). Private insurance programs grew rapidly, encouraged in part by Internal Revenue Service (IRS) rulings that employer contributions for health insurance were not taxable as employee income.[47] The public and private insurance systems operated in a way that almost completely insulated the payer and provider from estimates of cost, since they reimbursed the provider for virtually any measure taken. By 1982, 73 percent of all health bills were paid by government agencies or private insurance companies.[48]

There has also been rapid growth in both the number of cases treated and the intensity of care provided. Between 1960 and 1982, the number of physicians per capita grew 46 percent; the annual number of graduates in medicine grew 128 percent; the annual number of nurses graduated grew 146 percent; and the number of community hospital beds per capita grew 22 percent.[49] Hospital costs grew from 25 percent of health expenditures in 1940 to 40 percent in 1980. Using a relatively narrow definition of health care spending, health costs grew from 6.1 percent of the U.S. gross national product (GNP) in 1965 to 9.8 percent in 1981.

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[46] Clark Havinghurst, "The Contributions of Antitrust Law to a Procompetitive Health Policy," in Jack A. Meyer, ed., *Market Reforms in Health Care* (Washington, DC: American Enterprise Institute, 1983).

[47] Alan Enthoven estimates that revenue loss to government because of non-taxation of employer contributions to health insurance and medical expense deduction is as large as the Federal contribution to Medicaid and almost half the size of Medicare. See Alexander M. Capron, "Allocating Finite Resources: Questions of Equity and Access," in M.E. Lewin, ed., *The Health Policy Agenda: Some Critical Questions*, (Washington, DC: American Enterprise Institute, 1985).

[48] U.S. Department of Health and Human Services, *Health: United States* (Washington, DC: U.S. Government Printing Office, December 1985).

[49] Ibid.

The reasons for this growth are difficult to disentangle. Costs increased both because more people had access to the health care system and because advances in medical science increased the range of treatment. Rapid technical advances continued to drive the price of "recommended practice" to ever higher levels. Decisions about "how much is enough health care" became critical. Professional review organizations presided over the processes used to designate treatments as "prevailing professional custom and practice."[50]

As the complexity of the system grew, so too did the range of possible mistakes. Among other things, it was no longer possible to assume that a physician, competent at the time of original certification, would be competent in the revolutionary changes sweeping the medical field.[51] Consumers, increasingly aware of the range of their choices, began to question decisions made in their name. The result was regulation by tort law in the form of malpractice litigation. The issue of "prevailing professional custom and practice" came under courtroom examination, with the perverse effect that physicians were forced to include costly procedures even when there was only a small chance that the patient would benefit. Though the courtroom was a poor place to negotiate the issue of "how much is enough," it took on this role by default. This helped transform a decentralized and diverse system.[52]

During the 1970s, renewed interest in public health issues accompanied the explosive growth in clinical medicine. The National Highway Traffic Safety Administration and the Environmental Protection Agency began operation in 1970; the Consumer Product Safety Commission in 1972; the Mining Enforcement and Safety Administration, the Drug Enforcement Administration, and the Occupational Safety and Health Administration in 1973; and the Nuclear Regulatory Administration in 1975.[53] Capital spending for air and water pollution abatement rose from $700 million in 1965 (about 1 percent of total plant and equipment investment) to a peak of nearly $5 billion in 1975 (4 percent of total new plant and equipment) (all in 1972 dollars). The Surgeon General's office became more aggressive in forcing the country to recognize the dangers of smoking.

As medical costs reached 10 percent of GNP and health care enterprises grew to the size of major national corporations, it was no longer possible to maintain the fiction that the industry could be governed by the camaraderie of professional organizations. Taxpayers complained about the growing costs of Federal and State programs. Employers found that their contributions for health insurance co-payments had risen from 2.2 percent of wages in 1970 to 5.3 percent in 1984.[54] There was concern that an inefficient national health system was placing an intolerable burden on the costs of American products. There was also a reaction to the enormous costs of pollution abatement.

Attempts to make the health care delivery behave more like an ordinary market by creating a more perfect match between the interests of patients and the interests of privately owned firms in freely operating markets have proven to be extraordinarily difficult. For reasons discussed in the Health section of chapter 3, individuals face enormous problems in making informed choices about appropriate levels of health care. Even experts disagree about appropriate levels. Attempts to introduce greater market freedom have come to be coupled with extensive and complex regulations governing both price and practices. The result has been a system that is at once more free and more heavily regulated than the one it replaced. Federal payments, for example, are now governed by a precise schedule of hospital fees for "diagnostic groups" and plans are underway to regulate physician fees. Private insurers are negotiating with "preferred providers" for health care. At the same time, a 1984 survey of 1,115 firms indicated that 97 percent were taking specific steps to reduce health care costs.[55]

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[50] C. Havinghurst, "Decentralizing Decision Making: Private Contract vs. Professional Norms," in Jack A. Meyer, ed., op. cit., footnote 46, p. 24.

[51] Regulation of one's colleagues requires enormous fortitude, and there is every indication that it has not proven very effective. A peer review undertaken by the American Medical Association indicated that as many as 10 percent of active physicians were so impaired that they presented a danger to their patients. See *The New York Times*, June 4, 1984, p. A17.

[52] C. Havinghurst, op. cit., footnote 50.

[53] S. Breyer, *Regulation and Its Reform* (Cambridge, MA: Harvard University Press, 1982).

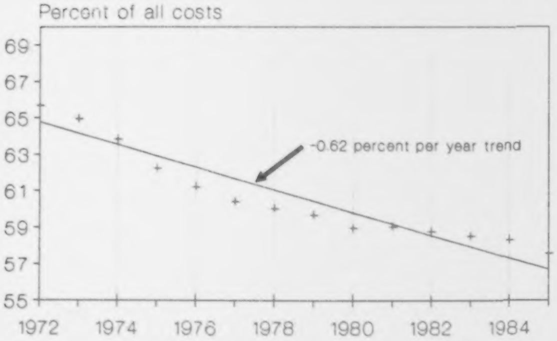
[54] Employee Benefit Research Institute, "Private Expenditures to Contain Health Care Expenditures," EBRI Issue Brief No. 55, Washington, DC, June 1986.

Network Components

The structure of the health industry has become increasingly complex in recent years, responding to the explosion of new technologies, to new professional specialties, and to the radical changes in the financial rules under which the health system operates. In general, the effect has been a proliferation of specialized treatment facilities, reduced use of hospitals, and increased use of out-patient treatment. Use of capital equipment has steadily increased. As in other service-oriented sectors, however, human skills are increasingly accompanied by sophisticated equipment. Figure 6-3 illustrates how labor costs have declined as a fraction of all hospital costs during the past 15 years. The decline is surprisingly unaffected by the radical changes in health care financing.

The drive toward efficiency has forced increases in the size of both hospital establishments and groups of physicians surrounded by a complex constellation of supporting organizations like testing laboratories, dialysis centers, hospices, nursing homes, and home health care providers. Patterns of ownership are in flux, as some of these specialized facilities are owned by large firms while many are independent.

Figure 6-3.-Direct and Indirect Labor Costs as a Percent of All Community Hospital Costs



SOURCE: American Hospital Association, *Hospital Statistics*, Chicago, IL, 1986 edition.

Changes in the financial system have also resulted in a movement toward private rather than public ownership. Even publicly owned facilities are managed more like private firms.

While there are differences in the quality of health care delivered in different parts of the country, the opportunities for health care businesses obviously follow population movements and provide employment and investment opportunities around the country. The rapidly growing areas of the south and west have furnished particularly attractive opportunities to health care enterprises well matched to the new financial rules. The increasing size of hospitals has reduced easy access to these facilities, but a variety of outpatient clinics, "urgi-centers," "doc-in-a-box," and other health facilities have proliferated in suburban areas. Rural areas are most likely to suffer a decline in health care access. At issue is whether the benefits of economies of scale in large facilities outweigh the benefits of short travel times to smaller facilities.

Although the effect of the changes just described on the quality of care delivered has proven difficult to measure over the entire Health network, the following examination of individual components reveals some interesting trends.

Physicians.—Cost containment by insurance programs, an actual decline in use of physician services resulting in part from rising prices,[56] and a potential "surplus" of physicians are in the process of restructuring the series of independent enterprises that were once at the center of medical practice in the United States. As a result, competition has begun to play a major role. The AMA's resistance to advertising has faded to a prohibition against "deceptive practices" and "creation of unjustified expectations."[57] Physician offices have extended their office hours, and some even make house calls. The most dramatic effect of competition, however, has been to force independent physicians into group practices. Instead of moving from medical school into lucrative private practices, an increasing number of certified physicians are finding that they must accept corporate employment paying $35,000 to $40,000 per year.[58]

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[55] The Wyatt Co., "1984 Group Benefits Survey," Washington, DC, 1984.

[56] Between 1976 and 1981, the average number of yearly physician visits per person declined from 4.9 to 4.6 while physicians in office-based practice rose 33.3 percent. See U.S. Department of Health and Human Services, National Center for Health Services Research, "Contacts with Physicians in Ambulatory Settings: Rates of Use Expenditures and Sources of Payment," Data Preview 16, DHHS Publication PHS 83-3361, Washington, DC, 1983.

[57] Robert M. Veatch, "Ethical Dilemma of For-Profit Enterprises in Health Care," in Bradford H. Gray, ed., *The New Health Care for Profit* (Washington, DC: National Academy Press, 1983), p. 128.

Aside from private practice, the different ways that physicians are now organized include:

- **Preferred Provider Organizations (PPOs) and Individual Group Practices.** The PPOs are loosely knit groups of private practitioners and hospitals that contract with employers and insurers to provide care at a discount, ranging from 5 to 30 percent on physician fees and 7 to 15 percent on hospital fees.[59] Physicians are typically paid on a salary basis. It is difficult to determine whether cost savings are real,[60] but the introduction of price competition undoubtedly puts pressure on prices. Between December 1984 and June 1985, enrollment in PPOs was estimated to have increased from 1.3 to 5.8 million.[61]
- **Health Maintenance Organizations (HMOs).** HMOs began with the encouragement of the HMO Act of 1973, which required businesses with 25 or more employees to offer an option for HMO care. HMOs have managed to replace professionally dictated standards with their own. Although Federal subsidies have stopped, HMOs have grown rapidly. Between 1981 and 1985, enrollees increased from 10.3 to 18.9 million, and membership may reach 40 to 50 million by 1990. The geographic pattern of their growth has, however, been uneven, and they have begun to dominate the practice of medicine in some parts of the country—in some large metropolitan areas 75 percent or more of all doctors participate in HMOs. HMOs are most active in urbanized areas of Hawaii, Minnesota, California, and Oregon, and are least important in rural areas in Mississippi, Montana, and Wyoming.[62] Most are new; in 1983, only half had been in business for more than 5 years.[63]

HMOs are organized using an entirely new principle in medical finance: they are self insuring. Patients pay a flat fee and rely on the HMO bureaucracy to provide needed treatment. This principle, coupled with the fact that the organizations can employ professional business managers to replace physician-dominated management of traditional health facilities, allows them to consider costs and benefits from a unique perspective. Not only do they create a unique regulatory environment from which to view alternative procedures, they create a unique bureaucratic environment for the physicians employed. There have been suggestions that one of the explanations for the lower rates of aggressive treatment administered at HMOs is that they do not attract the kind of personalities that practice aggressive medicine, and do not provide the kind of peer support for such actions that might be available in other kinds of practices.[64]

While data is ambiguous, HMOs appear to be able to provide health care at lower cost. Estimates indicate that HMOs can offer a wide range of services at prices 10 to 40 percent lower than fee-for-service expenses, even though the HMO patients receive as much ambulatory service (4.42 physician visits v. 4.19 fee-for-service).[65] HMO hospital admission rates were 40 percent lower than fee-for-service rates, while hospital stays averaged the same length. In 1981, average number of hospital days per thousand population for all payers was 1,316—for HMO members, it was 458. This could not entirely be explained by the difference in ages between HMO enrollees and other patients.[66]

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[58] Eli Ginzberg, "The Destabilization of Health Care," *New England Journal of Medicine*, vol. 315, No. 12, Sep. 18, 1986, pp. 757-760.

[59] D. Ermann and J. Gabel, "Preferred Provider Organizations: Performance Problems and Promise," *Health Affairs*, vol. 4, No. 1, spring 1985, pp. 24-40.

[60] U.S. Congress, General Accounting Office, "Constraining National Health Expenditures: Achieving Quality Care at an Affordable Cost," GAO/HRD-85-105, Sept. 30, 1985; and U.S. Congress, Office of Technology Assessment, *Payment for Physician Services: Strategies for Medicine*, OTA-H-294 (Washington, DC: U.S. Government Printing Office, February 1986).

[61] "PPO Enrollment Jumps Dramatically in 1985," *Hospital Week*, vol. 21, No. 40, October 1985, p. 1.

[62] Grady Wells, "Healthy Growth for HMOs," *American Demographics*, vol. 6, No. 3, March 1984, pp. 34-37, 46-47.

[63] N. Baker, J. McGee, and M. Shadle, "HMO Status Report, 1982-1983," Interstudy, Exelsiour, MN, August 1984.

[64] C. Havinghurst, op. cit., footnote 50.

[65] Employee Benefit Research Institute, op. cit., footnote 54; H.S. Luft, "How Do Health Maintenance Organizations Achieve their 'Savings'?" *New England Journal of Medicine*, vol. 298, 1978, pp. 1336-1343; and W.G. Manning et al., "A Controlled Trial of the Effect of a Prepaid Group Practice on Use of Services," *New England Journal of Medicine*, vol. 310, 1984, pp. 1050-1510.

Not surprisingly, HMOs initially faced great skepticism from both the public and physicians, but this resistance appears to be fading in the face of a growing consensus about the need for cost containment.[67]

Hospitals.—Spending for hospital care has increased rapidly, because (1) hospital use was encouraged (sometimes required) by most public and private insurance programs, and (2) hospital construction was encouraged by the Hill-Burton Act. There is evidence that these factors led to overuse of hospitals. For example, a study which reviewed 1,132 records of patients admitted to hospitals concluded that only 60 percent of the admissions were appropriate; 23 percent were judged to be "inappropriate" in that the examiners could determine "no positive benefit" from treatment in the hospital setting, and 17 percent of these could have been avoided with ambulatory surgery.[68] An independent study found that 19 percent of hospital admissions and 27 percent of hospital days were inappropriate.[69] A study of laboratory tests indicated that 47 percent of the tests performed in a teaching hospital could have been eliminated without any apparent loss in the quality of patient care.[70]

While such conclusions are controversial, cost reduction programs have put unrelenting pressure on hospital systems to reduce expenses, by increasing efficiency and—to an extent that is difficult to determine—by eliminating implicit cross-subsidies that had the effect of supporting teaching, research, and care for the indigent by overcharging patients able to pay.

Recent trends in hospital care include:

- The numbers of full-time in-patients, the rate of hospital admissions, and admission rates for the elderly all fell sharply in 1985. Average hospital stays were 7.7 days in 1975 and 7.1 days in 1985;[71] hospital occupancy rates fell from 80 percent in 1970 to 69 percent in 1985.[72] This alone led to great pressures to close inefficient facilities.

  Industry studies assert that changes in insurance coverage provided by Deere & Co. of Illinois resulted in a 21 percent decline in hospital days per 1,000 beneficiaries over a period of 36 months; a major insurance company reported savings of $523 per patient in 1981 all because of ambulatory surgery and pre-admission testing.[73]
- Although in-patient costs are still growing, the rate of growth has slowed considerably and the average length of a hospital stay has been reduced.[74] In-patient expenses per capita increased 12.6 percent between 1976 and 1982, but only 4.5 percent per year after 1983.
- Competitive pressure has forced hospitals into horizontal integration (in the form of hospital chains) and other services, such as clinics, nursing homes, and ambulance companies, into vertical integration. Some have even diversified into real estate and resort management.[75] An increasing fraction of hospitals are being operated as parts of chains rather than as independent community-based facilities.

  Between 1975 and 1982, multi-hospital systems increased their share of all community hospitals from 25 to 33 percent.[76] Ownership of multi-hospital chains is dominated by five large companies that own 6 percent of all U.S. acute-care beds, and nearly 50 percent of all for-profit beds. The number of beds owned by these firms grew from 29,000 in 1976 to 62,000 in 1982. Their holdings are concentrated in the South and West, where hospital construction was most rapid during the past two decades.[77]

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[66] R.J. Arnold, L.W. Debrock, and J.W. Pollard, "Do HMOs Produce Specific Services More Efficiently?" *Inquiry*, No. 21, 1984, pp. 243-253.

[67] C. Havinghurst, op. cit., footnote 50, p. 30.

[68] A.L. Siu et al., "Inappropriate Use of Hospitals in a Randomized Trial of Health Insurance Plans," *New England Journal of Medicine*, vol. 315, No. 20, Nov. 13, 1986, pp. 1259-1266. This study examined records from Seattle, Dayton, Fichburg and Franklin Counties in Massachusetts, and Charleston and Georgetown Counties in South Carolina. Upper income (>$61,000 family income) families and families on Medicare were excluded.

[69] J.D. Restuccia et al., "The Appropriateness of Hospital Use," *Health Affairs*, vol. 3, No. 2, summer 1984, pp. 130-138.

[70] A.R. Martin et al., "A Trial of Two Strategies to Modify the Test Ordering Behavior of Medical Residents," *New England Journal of Medicine*, vol. 303, 1980, pp. 1330-1336.

[71] American Hospital Association, *Hospital Statistics: 1986* (Chicago, IL: American Hospital Association, 1986), p. xvii. There were actually 8 percent *fewer* people in hospitals in 1985 than there were in 1975.

[72] Ibid., p. 2.

[73] R. Kauer, "Deer & Company: Utilization Review," Health Systems Management Center, Case Western Reserve University, under contract with the Business Round Table Health Initiative Task Force, 1983; and Employee Benefit Research Institute, op. cit., footnote 54.

[74] "Medicare Prospective Payment and the American Health Care System: Report to the Congress," February 1986.

[75] L. Punch, "Contract Management Companies Manage Growth Rate of 13.3 percent," *Modern Health Care*, vol. 14, August 1984, pp. 45-52.

[76] D. Ermann, and J. Gabel, "Multihospital Systems: Issues and Empirical Findings," *Health Affairs*, vol. 3, No. 1, spring 1984, pp. 50-64.

While scale economies have encouraged horizontal integration, there has been some vertical disintegration as hospitals have elected to contract for specialized services (housekeeping, food services, emergency services, plant operations and maintenance, records keeping, billing, and collection).[78]

- The average numbers of beds per hospital has also risen. In some cases this has led to economies of scale. The number of hospitals with fewer than 100 beds fell 8 percent between 1975 and 1985, while hospitals with more than 300 beds increased their share from 45.8 percent of all beds to 47.8 percent.[79]
- An increasing number of hospital patients are now treated privately, and more hospitals are privately owned. Public facilities faced enormous difficulties because of competitive pressures and the increasing difficulty of obtaining funding from philanthropic or public funds.[80] In many cases, costs may have been difficult to contain because of the large number of indigent patients. Between 1975 and 1985, the number of beds in investor-owned facilities increased from 7.7 to 10.3 percent of non-Federal hospitals.[81] Even not-for-profit hospitals are hiring private hospital firms to manage their operations. From 1970 to 1981, hospitals operated under contract management increased from 14 to 497.[82]
- Cost containment in standard hospitals, coupled with growing consumer interest, has spawned rapid growth in specialty hospitals. More than one-third of all private hospitals now specialize in psychiatric care, alcohol and drug abuse, physical rehabilitation, or the care of women.[83]

Clinics.—Free-standing clinics and sophisticated services offered in physician group practices are introducing new competition for hospitals. There were 1,800 to 2,000 such centers in 1983,[84] approximately 23 percent of which were controlled by three companies.[85] Technology now allows many procedures to be conducted out of hospitals and many insurers encourage the use of the less expensive clinics, where for some procedures rates average 55 percent less than hospital in-patient rates and 18 percent less than hospital out-patient rates.[86] Many of these centers are owned by individual physicians or partnerships, but in some cases hospital chains are diversifying to own smaller facilities themselves.

Support Facilities.—Expanded options for care have produced many specialized organizations designed to serve specific market niches. For example, there are now 1,200 centers that provide dialysis and many clinical laboratories that conduct medical tests. Because medical science has improved diagnosis faster than treatment there has been a growing demand for hospices, where patients with known but essentially untreatable illnesses can be made comfortable. There were 1,345 hospices in 1984, increasing at a rate of 1 per day.

Similarly, the rapid growth in the ranks of the elderly, and the failure of medicine to provide cures for the chronic illnesses of old age, has led to an expansion of nursing homes. This trend has been accentuated by the number of women wishing to remain in the work force, who are therefore unprepared to care for an aging parent.

The costs of these facilities, about half of which are paid by Medicaid funds, already represent nearly 10 percent of all health expenditures. This expense has led a number of States to take draconian actions to block further cost increases. The number of nursing home beds grew 3.7 percent annually between 1971 and 1976 but growth slowed to an annual rate of 2.4 percent between 1976 and 1982 in spite of a 4.5 percent annual increase in the number of persons over 85. By 1984, nine States ordered a halt to nursing home construction, and others were limiting approvals to retirement housing and life care.[87] Levels of service vary enormously depending on the policies in individual States. There were 94 nursing home beds per 1,000 elderly in Wisconsin in 1980, and 22 per 1,000 in Florida.

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[77] R.B. Siegrist, Jr., "Wall Street and the For-Profit Hospital Management Companies," in Bradford H. Gray, ed., op. cit., footnote 57.

[78] In 1983, growth rates in contractual services ranged from 18 to 200 percent. See L. Punch, op. cit., footnote 75.

[79] *Hospital Statistics: 1986*, op. cit., footnote 71, p. xvii.

[80] Ibid.

[81] Ibid., pp. 3-4.

[82] J.W. Salmon, "Organizing Medical Care for Profit," in J.B. McKinlay, ed., *Issues in the Political Economy of Health Care* (New York, NY: Tavistock Publications, 1984).

[83] M. Freudenheim, "Specialty Health Care Booms," *The New York Times*, Nov. 25, 1987, p. D1.

[84] G. Richards, "FECs Pose Competition for Hospital EDs," *Hospitals*, Mar. 16, 1984, pp. 72-82; and "National FEC Group Changes Name," Oct. 1, 1984, p. 22.

[85] H.J. Henderson, "Surgery Centers Double," *Modern Health Care*, vol. 15, June 7, 1985, pp. 148-150.

[86] C. Ansberry, "Outpatient Surgery Rises as Firms Push to Reduce Health-Care Costs," *The Wall Street Journal*, Feb. 20, 1985.

Most nursing homes are now in small private chains of 2 to 7 facilities with interlocking ownerships, but concentration is increasing. The five largest investor-owned chains increased their share of beds from 64 to 73 percent between 1982 and 1983.[88] While most facilities do not provide much more than routine convalescent care (two-thirds of all jobs are for orderlies, therapy assistance, food service, laundry, and housekeeping), a number have begun to offer a series of diversified services. Some are specializing in areas like physical and respiratory therapy, home health care, adult day care, residential retirement, and life care.[89] All are seeking to increase service for patients covered by private rather than public insurance.

Home Health Care.—Home health care has increased dramatically as regulatory programs reduce the frequency and length of hospital stays, transferring health care costs to the home (usually to women, see note 111, p. 391). A growing number of home health care services are now covered under public and private insurance. Medicare reimbursements for home health care grew 376 percent between 1976 and 1983.[90]

In response to growing demand, a variety of new technologies have been developed that permit an increasing range of treatment at home. For example, technology now permits oxygen therapy for emphysema and IV-nutritional therapy to be conducted at home more cheaply than in the hospital. The implantable pump is an example of a highly sophisticated device that, like the implantable heart pacemaker, makes it possible for the patient to carry a sophisticated piece of equipment inside the body cavity and to become completely ambulatory. There will soon be a version that can be reprogrammed by a physician, and eventually through sensors in the body itself. About 15,000 implantable pumps are now in place, primarily for delivering chemotherapy for liver cancer, morphine for intractable pain, and insulin for diabetics. The manufacturer estimates that costs, including the initial cost for surgical implantation, would be $17,000 for one year of treatment with the implantable pump—as opposed to $65,000 for one year of conventional therapy.[91]

Technology also makes it possible for comparatively small firms to maintain the sophisticated record keeping needed in modern medicine. Comparatively inexpensive systems can maintain financial records, personnel and payroll records, records of billable activities, and the voluminous forms required by the Health Care Finance Agency.[92]

Less complex equipment is available without prescription at retail stores. There has been a sharp increase in sales of incontinence products, cardiac monitoring equipment, diabetes therapy products, home nutrition products, kits for colon disease, and infections.[93] Monoclonal antibodies have made it possible to offer a wide variety of sophisticated diagnostic kits to the home market and there is a large market for herpes virus testing and home screening for pregnancy, ovulation, venereal disease, and strep infections. If they are properly used, these systems can also reduce health care costs.

A number of small agencies have grown up to serve the exploding need for home health care services. What was once a not-for-profit service has become a profitable enterprise. Investor-owned agencies increased share of home health care from 5.0 percent in 1978 to 26.7 percent in 1984. Most firms are small (averaging 45 employees) and depend heavily on Medicare. Services provided range from housekeeping to training family members in the operation of complex home care equipment.

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[87] K.A. Fackelmann, "Nursing Home Crunch to Hit Hospitals Soon," *Modern Health Care*, vol. 14, Nov. 15, 1984, pp. 42-46.

[88] B.C. Vladeck, *Unloving Care* (New York, NY: Basic Books, 1980), and L. Punch, "Chains Expand Their Operations, Expecting Prospective Pay Boom,"*Modern Health Care*, vol. 14, May 1984, pp. 131-140.

[89] A. Renschler, "Testimony Before the Subcommittee on Aging," U.S. Senate, Committee on Labor and Human Resources, pp. 79-86, 1983; and P.G. Hollie, "Nursing Homes Seek Affluent," *The New York Times*, pp. 31, 33, Sept. 15, 1984.

[90] U.S. Senate, Special Committee on Aging, "Medicare and the Health Costs of Older Americans: The Extent and Effects of Cost Sharing," Washington DC, April 1984.

[91] "Implantable Drug Infusion Pump," *Issues in Health Care Technology*, vol 5, No. 2, pp. 1-3, 1982; and "Johns Hopkins/NASA/Industry-Developed Implantable Infusion Pump," Blue Sheet, Johns Hopkins University, Baltimore, MD, Mar. 7, 1984.

[92] M.A. Beachler, "What a Computer Can Do for a Home Health Agency," *Caring*, vol. VI, No. 6, June 1987, p. 5.

[93] B. Edmondson, "The Market for Medical Self-Care," *American Demographics*, No. 51, pp. 35-37.

Drug stores and other retail outlets have become more efficient in their ability to serve home health care needs. There has been rapid growth in over-the-counter sales of drugs (9 percent annually since 1972). Computers operated by retail pharmacists can now keep track of patients' records, and help to identify possible adverse drug combinations. Retail operations have also become more efficient in inventory control, ordering, billing, and invoicing.

Measuring Productivity

How well does each component of the complex Health network do its job, and how well does the system operate as a whole? The increasing complexity in the health care system has made the second question more important than at any time in the past. Answering this question involves addressing several other issues:

- What is known about the factors contributing to the incidence of disease, the methods available for reducing risk factors, and the way investments in prevention compare with investments in treatment?
- What is known about the costs and benefits of alternative methods of delivering medical care?
- Is society allocating its resources to different classes of individuals equitably and in a way most likely to minimize costs?

The retrospective system of payment that prevailed in public and private insurance until recently encouraged procedures that exceeded any reasonable estimate of benefit, and in some cases may actually have encouraged practices that entailed more risk than benefit. These procedures continue even under the current payment system, as witnessed by the case of fetal monitoring—a technique shown to be of no benefit and some risk in most cases.[94]

Disagreements, or lack of information about the relative effectiveness and costs of different courses of medical treatment, lead to wide variations in the way medicine is practiced around the country.[95] For example:

- In Maine, the probability that a woman has a hysterectomy is 20 percent in some markets and 70 percent in others.[96]
- Table 6-4 summarizes a recent study that revealed enormous differences in the rates at which different procedures were performed in hospitals around the country. The differences are extremely large even for costly and dangerous procedures, like coronary-artery bypass surgery where rates differed by a factor of 3.1 in the facilities studied. Unfortunately the authors of the study had no basis on which to estimate whether the high rates were too high or the low rates too low: "the available data do not allow us to explain the wide variations we have observed. In addition, we cannot establish the 'correct' use rates from these data."[97]

The rules governing the financing of a health care organization may influence the kind of care provided. Patients of physicians who owned X-ray equipment, for example, are more likely to receive an X-ray and less likely to see a radiologist than those of physicians who did not.[98] In a recent experiment, a series of case histories involving heart problems was reviewed by cardiologists with no personal interest in the cases. Physicians in independent fee-for-service practices were significantly more likely to recommend tests and surgery than those working for prepaid group practice.[99] However, the rules governing the allocation of costs between patient and insurance company do not seem to have a significant effect either on the total cost of health care, or on the priority with which funds are spent.

New Technologies and System Integration

Emerging information technologies offer great potential for achieving a new kind of integration in the

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[94] R. Neutra et al., "Effect of Fetal Monitoring on Neonatal Death Rates," *New England Journal of Medicine*, vol. 299, Aug. 17, 1978, pp. 324-326.

[95] J.E. Wennberg, J.P. Bunker, and B. Barnes, "The Need for Assessing the Outcome of Common Clinical Practices," *Annual Review of Public Health*, vol. 1, 1980, pp. 277-295.

[96] J.E. Wennberg, "Variations: A Proposal for Action," *Health Affairs*, pp. 7-32.

[97] M.R. Chassin et al., "Variations in the Use of Medical and Surgical Services by the Medicare Population," *New England Journal of Medicine*, vol. 314, 1986, pp. 285-290.

[98] A.W. Childs and E.D. Hunter, "Non-medical Factors Influencing the Use of Diagnostic X-ray by Physicians," *Medical Care*, vol. 10, No. 4, July/August 1972, pp. 323-335.

[99] M.A. Hlatky, E. Botvinick, and B.Brundage, "A Controlled Comparison of Cardiac Diagnostic Test Use in a Health Maintenance Organization," paper presented at annual meeting of the Robert Wood Johnson Clinical Scholars, San Antonio, TX, Nov. 11-14, 1981.

Table 6-4.—Variations in the Use of Medical and Surgical Services

Procedure	Coefficient of variation	Highest/lowest rate ratio
Injection of hemorrhoids	0.79	26.0
Hip arthroplasty	0.69	11.4
Destruction of benign skin lesion	0.67	8.0
Skin biopsy	0.58	4.8
Humeral fracture repair	0.51	7.9
Total knee replacement	0.47	6.0
Lumbar sympathectomy	0.44	4.0
Coronary-artery bypass surgery	0.41	3.1
Carotid endarterectomy	0.39	4.0
Hiatus hernia repair	0.38	5.9
Excision of malignant skin lesion	0.37	3.3
Coronary angiography	0.32	2.3
Excision of benign breast lesion	0.31	2.2
Craniotomy	0.31	2.6
Total hip replacement	0.31	3.0
Arterial grafts of lower extremities	0.28	3.5
Colles' fracture repair	0.25	2.3
Bronchoscopy	0.21	2.2
Appendectomy	0.19	2.2
Abdominal aortic aneurysm repair	0.19	2.2
Mastectomy	0.17	2.7
Diagnostic upper gastrointestinal endoscopy	0.16	1.6
Colectomy	0.15	1.6
Prostatectomy	0.12	1.7
Lens extraction	0.11	1.5

SOURCE: M.R. Chassin et al., "Variations in the Use of Medical and Surgical Services by the Medicare Population," *New England Journal of Medicine*, vol. 314, 1986, pp. 285-290.

Nation's health care system that would reduce costs and improve the quality of services rendered. In many cases, new devices can contribute a qualitatively new service; in others, they can so improve the speed and accuracy of procedures that their costs may be reduced to a point where they are offered routinely. For example, computer aided diagnostic and treatment systems can provide systematic second opinions for complex decisions. Such devices are already available for general abdominal pain, lung and thyroid diseases, glaucoma, cancer, and even neurological and psychiatric problems. These systems are unlikely to displace a physician's judgment, but at a minimum they can play a role in eliminating simple mistakes.

Computers and communication equipment can also play a powerful role in rationalizing the management of different parts of the health care system, as they have in other business enterprises. For hospitals, record keeping is a major expense that has grown rapidly with the introduction of complex cost containment reporting requirements. New information technology can have a dramatic impact on the efficiency with which records are maintained. Automated ordering and invoicing systems can control overhead while ensuring that adequate supplies of a large number of items are in stock without maintaining large inventories.

Information technologies can also improve the quality of clinical medicine by coordinating information about individual cases and maintaining patient records in a way that makes it easy to review alternative programs of therapy. In this way, physicians can benefit from the collective knowledge of case histories instead of relying on their own experience and that of their immediate colleagues, as is the case today.

Hospital investment in information-processing equipment has been spectacular. Information system costs have now grown to 2 percent of the overall hospital budget, second only to investments in the hospital building itself. At present, 60 percent of system capacity is used for billing and collections, 22 percent for in-patient care, 13 percent for ordering tests and drugs, and 5 percent for management information.[100] Many more applications are expected soon and equipment purchases are expected to increase by a factor of four between 1984 and 1990. Applications range from improved software for interpreting data from CAT, MRI (magnetic resonance imaging), X-ray, and other diagnostic equipment; advanced systems for designing and operating prosthetics (like artificial joints and limbs); improved record keeping that may combine efficient bookkeeping with an intelligence capable of detecting obvious errors; and improved telemetry for connecting homes and ambulances to professional facilities.

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[100] "Hospital Systems' Expenditures Skyrocket," *Hospitals*, April 1, 1984, p. 39.

HOUSING[101]

Prospects

The U.S. housing construction industry has been called the "industry that capitalism forgot." Compared with other manufacturing enterprises, the industry is fragmented and decentralized, with little investment in plant improvement, new equipment, or permanent staffing. It conducts virtually no research on either its products or the techniques by which products are assembled. Innovation has resulted almost entirely from component and equipment suppliers.

Productivity in the construction industry as a whole appears to be falling. Few builders have adopted the optimum engineering techniques, innovations in basic materials and structural designs, or performance analyses which have been applied to nearly all major products manufactured by other U.S. industries. A typical home, for example, has about 15,000 parts—approximately the same number as an automobile—but is assembled almost entirely by hand at the construction site.

The construction industry may be on the brink of a major change as modern production technology and the threat of imports force basic changes in the industry's products, in its production process, and in the way its goods are marketed:

- The industry could turn increasingly to factory assembly of products and components. These production facilities could be efficient, flexible, and enjoy the productivity increases that are being obtained in other manufacturing enterprises. Field assembly could be rapid, with entire homes assembled in a day. Increased investment in research could lead to major improvements in housing and other construction products. Housing could be made more comfortable and less expensive to operate, using new technologies ranging from advanced windows to efficient appliances. Homes could be sold through outlets that would permit prospective clients to participate in the design of a new house, or to be given a video tour of existing structures.
- The industry could remain largely unchanged, with productivity declining. Housing prices could rise with respect to other amenities. The Nation could be burdened with poorly constructed products that would become an increasing burden if energy prices rise during the next few decades. Foreign suppliers could provide increasing amounts of the value-added through components (e.g., major appliances and fittings), construction equipment (everything from hand tools to heavy construction equipment for tunneling), and licenses. Americans could find themselves assembling foreign products with foreign tools and adding little value other than site preparation.

Housing and other types of construction operate with relatively few direct government regulations, other than the highly fragmented set of building codes typically operated at the local level. Compared with the extensive public support for research in the farming industries, total public spending on housing research is negligible. With 9 million people, Sweden supports more research on home construction than the United States; virtually all U.S. housing research is supported by the U.S. Department of Energy.

Structure and Performance

A diverse collection of enterprises combines to provide Americans with comfortable homes. Of the funds spent on the Housing amenity, however, one-third of the value-added ends up in the real estate

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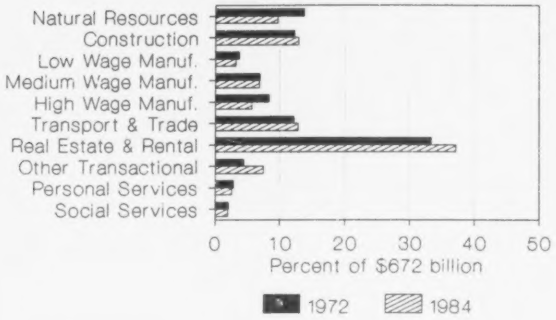
[101] Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Construction," sector study, 1987.

Figure 6-4.-Value-Added To Meet Demand for Housing ($672 billion* in 1984)



*Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

industry (see figure 6-4), most in the form of direct returns to capital invested by homeowners or other investors. Since these costs result from factors largely unrelated to the structure of production, they are not examined here. There is little opportunity to change land costs, or the cost of home financing, through changes in production recipes in construction. Price changes in these areas result from a variety of factors discussed at some length in chapter 3.

Approximately 16 percent of the spending for Housing results in value-added in the manufacturing firms that produce appliances, furniture, and housing components for housing (as well as value-added generated indirectly by suppliers of these firms; the system for producing these products is discussed more fully in the last section of this chapter). About 10 percent of the value-added in Housing goes for energy or raw materials.

Only about 13 percent of all the value-added in the U.S. economy resulting from Housing ends up in the Construction sector. Most of this results directly from home construction, but some arises from the need to construct facilities that provide energy for housing and from other indirect effects. Housing provides by far the largest market for Construction activities, accounting for almost 48 percent of value-added in that sector.

For convenience, the industry that meets intermediate demands for construction (dams, harbors, bridges, roads, sewers, hospitals, and office buildings) will also be examined in this section.[102] The network of industries associated with this kind of construction includes architecture, engineering, field erection, component production, maintenance, and repair.

Factors Forcing Change

There are several reasons for the lack of progress in the U.S. housing construction industry. The most important is undoubtedly the enormous uncertainty ties in demand. Demand for construction business can change by as much as 50 percent in one year. Most firms achieve the flexibility required under these circumstances by minimizing use of permanent staff and long-term capital investments. The ratio of capital to labor in construction, after increasing by 4.2 percent per year between 1950 and 1968, declined by 0.8 percent per year during the early 1970s.[103]

The industry is highly fragmented and decentralized. While some vertical integration exists, most projects involve teams assembled from different parts of a network. Most construction firms are relatively small; of the 558,000 U.S. construction firms in 1982, only 10 percent had more than 19 employees.[104] There are few barriers to entry, particularly for homebuilders. Less than 8 percent of homebuilders have annual sales of over $1 million.

This fragmentation is encouraged in part by the fragmented form of regulation governing the industry. The homebuilding industry is regulated almost entirely at the State and local level. Currently, local governments apply several thousand major and minor variations of four model codes. There are at least as many inspection systems, accounting for differences in building code interpretations and varying degrees of enforcement. The various fire safety codes and inspections systems that relate to buildings compound this regulatory complexity. Enforcement systems also vary, both among and within States. This complex system presents problems for large U.S. homebuilders. The producer must satisfy hundreds if not thousands of building codes and inspection systems in order to serve the national market and still abide by the law. In addition to creating difficulties for large firms attempting to ship products to many different locations,[105] this array of State and local building codes and differing inspection practices can present obstacles to technological innovation.

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[102] As defined by the U.S. Office of Management and Budget (OMB), the construction industry actually consists of many different subindustries: Standard Industrial Classification (SIC) code numbers 15, "general building contractors and operative builders"; 16, "heavy construction general contractors"; and 17, "special trade contractors." In addition, "subdividers and developers," a subdivision of real estate (SIC code 65), is included in statistics on the construction industry.

[103] H. Kemble Stokes, Jr., "An Examination of Productivity Decline in the Construction Industry," *The Review of Economics and Statistics*, vol. 63, No. 4, November 1981, pp. 495-502.

[104] U.S. Small Business Administration, *The State of Small Business, 1985* (Washington, DC: U.S. Government Printing Office, 1985), Table A1.21.

Many of the features that have led to the existing industrial structure are changing. The construction industries in Japan and Sweden have moved rapidly to substitute factory construction for on-site hand labor. In Sweden, over 90 percent of new homes are made in factories.[106] In Japan, homebuilding is moving into the hands of large firms (e.g., Matsushita and Sekisui Chemicals) with a large capital base and a large investment in research engineering.[107]

Factory assembly offers a number of potential advantages. The factory permits greater quality control, greater use of modern fabrication equipment, and better working conditions. A factory-assembled home can be erected quickly on a site, minimizing construction loans and disruptions due to poor weather and offers the potential for greater flexibility of design. All of these advantages are moot, of course, if fluctuating demand leaves the equipment idle.

In the United States there has been a partial movement toward factory construction. Most U.S. factory construction, however, is essentially hand-assembly indoors. Very little capital equipment is used. In addition to the problem faced by fluctuating demand, factory-based homebuilding firms face an important marketing barrier in the United States. While factory construction is associated with "brand name" reliability and quality in places like Japan and Sweden, it is associated with cheap "pre-fab" and mobile homes in the United States.

Intermediate Demand for Construction

The rapid growth of service-related industries and the comparative decline of employment and investment in manufacturing and natural resource activity are both reflected in shifting patterns of intermediate demand for construction. Buildings taken as a whole have retained a surprisingly constant share of all investment in structures during the past 35 years, capturing approximately 70 percent of all public and private investment in structures. The rapid fluctuations in demand for new residential construction are compensated partly by activity associated with renovation and remodeling, and partly by the fact that changing demand for non-residential building construction does not respond as rapidly to the changes in interest rates and other factors that lead to collapsing markets for new homes.

There have, however, been significant shifts in the composition of non-residential building construction. Rapid growth in service employment has meant that between 1976 and 1985, commercial building space and government offices grew from about 56 to 70 percent of all investment in buildings. During the same period, hospitals and educational facilities fell from 21 to 12 percent of building investment. Investment in industrial buildings fell from a peak of nearly 25 percent of all building activity in 1979 to 15 percent in 1985.

There has been a striking decline in the share of construction work slated for highways, sewers, water projects, and other infrastructure investments (see figure 6-5). This decline has continued in spite of a significant rise in investment in highway construction between 1982 and 1986 (outlined in the Transportation discussion of this chapter). Declining investments in new electric generating facilities, new pipelines, and other energy-related projects counted as "structures" led to a sharp decline in energy-related construction work in the 1980s.

Network Components

Heavy Construction.—Most major civil engineering projects, power plants, and large office complexes are constructed by relatively large builder/

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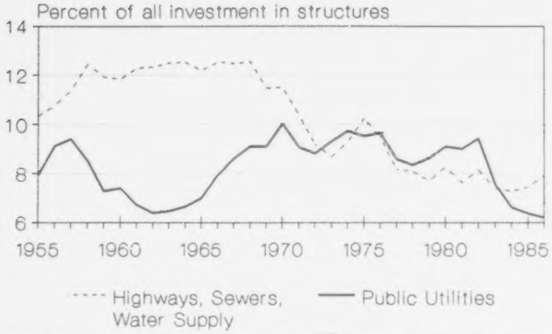
[105] U.S. Congress, Office of Technology Assessment, *Technology, Trade, and the U.S. Residential Construction Industry—Special Report*, OTA-TET-315 (Washington, DC: U.S. Government Printing Office, September 1986), p. 70.

[106] L. Schipper, A. Meyers, and H. Kelly, *Coming in From the Cold: Energy Efficient Housing in Sweden* (Cabin John, MD: Seven Locks Press, 1986).

[107] James McKeller, "Industrialized Housing: The Japanese Experience," Alberta Department of Housing, Alberta, Canada, December 1985, p. 81.

Figure 6-5.-Investments in Infrastructure (percent of all structures in constant 1982 dollars)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 5.5.

developers or general contractors. The top firms generate more than $1 billion in annual revenue and account for 40 percent of domestic contracts. However, many of these large firms have faced serious financial difficulties in recent years, due to the decline of large domestic projects; receipts for the largest companies fell by 30 percent between 1981 and 1983.

Although some firms have offset losses through foreign contracts, competition has grown for major international projects. Foreign firms have captured markets that were once the domain of U.S. giants. The problems of the U.S. nuclear industry, for example, have eroded the position of such major American companies like Bechtel in international markets. At the same time, Japanese, French, and West German firms—many of which began with American licenses—capture increasing shares. Many foreign firms offer advantages that the U.S. firms cannot match such as discounts on materials such as steel and concrete as part of a government-sponsored package that includes design and engineering.

Home Builders.—The homebuilding industry includes many small firms, but larger companies have begun to dominate housing output. In 1986, for example, homebuilders with annual volume greater than 100 units produced 67 percent of domestic units—up from 7 percent in 1959.[108] Moreover, the share of major firms has grown over the past two decades, reflecting trends in the industry as a whole.

Most homebuilding enterprises in the United States continue to operate on a small scale. A National Association of Home Builders (NAHB) survey conducted in 1979 showed that 46.7 percent of NAHB's member firms were run by either the principal or the sole owner, while only 8.1 percent had a salaried executive. The average U.S. builder produces 5 to 10 units per year. Most homebuilders serve specific local markets; less than 15 percent of all homebuilders do business outside of their home State.[109] These firms move rapidly into other lines of work during periods of low housing demand. In the "bad years" of 1967, 1974, and 1975, nearly 20 percent of all NAHB members switched to other businesses.

Even the comparatively large firms that build homes or home components in factories—which average 320 homes per year[110]—are not large by the standards of most manufacturing facilities.

Subcontracting to specialized firms accounts for a growing share of construction activity. In 1976, 58 percent of U.S. homebuilders contracted over three-quarters of their construction activities, as opposed to one-third in 1969. Firms reporting that subcontracts accounted for less than one-quarter of their work fell from 19 to 10 percent during the same period. Over 90 percent of all industry receipts were paid to subcontractors in 1977.[111]

Market concentration has increased in both conventional and factory-based construction. The top 100 production builders now control about 25 percent of the market, up from 17.3 percent in 1978.[112] The top 25 "manufactured" (mobile) home producers controlled 74 percent of the total market in 1983. Concentration in the metal buildings industry is particularly high, with the top 30 companies controlling over 95 percent of the market.

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[108] National Association of Home Builders, "Housing Focus," news release, Washington, DC, November 1987.

[109] F.T. Ventre, "On the Blackness of Kettles: Inter-Industry Comparisons in Rates of Technological Innovation," *Policy Sciences*, vol. 11, 1980, pp. 309-328.

[110] Renee Mathieu, "The Prefabricated Housing Industries in the United States, Sweden and Japan," *Construction Review*, vol. 33, July-August, 1987, p. 20.

[111] U.S. Department of Commerce, Bureau of the Census, *1977 Census of Construction Industries*, Washington, DC, April 1980.

[112] *Automation in Housing and Manufactured Home Dealer*, various issues.

Remodelers.—The remodeling and reconstruction industry has even greater diversity and flexibility than producers of new structures. Traditionally, many firms have worked in both areas, partly to protect themselves against market fluctuations. Newer firms, however, often specialize in renovation, even going so far as to specify types of structures. NAHB finds that the largest and smallest construction firms tend to limit their work to new structures, while many intermediate size firms engage in both new construction and remodeling.

The renovation industry is becoming an increasingly distinct business specialty. Over 90 percent of all NAHB members that do remodeling have ceased all other operations. The use of specialized subcontractors has also increased, particularly when renovation is undertaken to improve energy efficiency or safety; this generally involves electrical and plumbing experts. Renovation places a high premium on worker skills, since unexpected developments often accompany the opening of older structures for repair.

Investment in building improvements, additions, alterations, and replacements represent a growing share of construction activity. A survey by the 600 largest U.S. construction firms put reconstruction at approximately 40 percent of total construction activity in 1984 and 1985; that figure was 26 percent in 1979. Disagreement about the potential future growth of the renovation market arises from a poor understanding of its framework. Traditionally, rehabilitation rates have been highest during slack periods in the new construction market, but this pattern may be changing.[113] Differences between the cost of new construction and the cost of extensive renovations have decreased. One cause of high renovation and rehabilitation costs is the inherent uncertainty in entering an older structure. As a result, most renovation contracts are negotiated, and are not subject to competitive bidding. This reduces pressure to reduce costs or improve efficiency.

Accelerated depreciation of new structures often favors new construction over renovation. Nevertheless, tax credits for historic preservation and other indirect subsidies for renovation can encourage renovations in certain areas. Renovated commercial properties may rent for less than new structures.

Measuring Productivity

Inadequate funding for construction research and the inability of industry firms to make permanent investments in people or equipment explain much of the stagnant or falling productivity in the U.S. construction industry. A number of other explanations have been offered as well:

- deflators may fail to account for changes in construction quality (like the obvious improvement in energy efficiency offered by new homes);
- repair and maintenance work may be underreported;
- off-site assembly of components may shift high-productivity activity into manufacturing industries and out of the construction industry, leaving comparatively unproductive site-work in construction; and
- there has been comparatively rapid growth in young, non-union construction workers during the past decade.[114]

The pace at which innovation is accepted by local codes provides a good measure of rates of change in the industry. A study of 14 technologies (including non-metalic electric cable and wood roof trusses) showed that 20 years typically passed between the time when 10 percent of all codes accepted the change and 90 percent accepted the change.[115]

Builders, whose financial position makes it difficult for them to tolerate mistakes, are extremely sensitive to possible negative consumer reaction. Unions have also resisted change; their effect has been to slow the introduction of innovations.

New Technologies and System Integration

New construction technologies and higher energy costs have already had a noticeable effect in changing the nature of the structures themselves—how buildings are manufactured, and how they may be adapted for differing conditions and uses. Often buildings can only be made to operate efficiently when the construction and future operating costs are considered as an integrated design problem. Institutional problems and the lack of research targeted at net building design and performance (particularly for residences) has limited progress. Often the cheapest way to reduce the heating or air-conditioning costs of a building involves good basic design.

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[113] Duane T. McGough, "Additions to the Housing Supply by Means other than New Construction," U.S. Department of Housing and Urban Development, Office of Policy Development and Research, Washington, DC, December 1982.

[114] *Technology, Trade, and the U.S. Residential Construction Industry*, op. cit., footnote 105, pp. 31-33.

[115] Ventre, op. cit., footnote 109, p. 319.

New computer-based systems can improve the productivity of building design and analysis in a number of ways. They can rapidly convert concepts to drawings, drawings to analysis, and can combine these steps in order to estimate initial and operating costs. Such systems might be used to prepare both working sketches and detailed drawings. For example, a draftsman could call a computer file with routine building components at a moment's notice, thus bypassing the tedious aspects of drafting. Price lists could be included, allowing for instantaneous projection of the cost of various design alternatives. Computer assisted design systems could aid the designer by removing many of the barriers between inspiration and execution, and could improve client-designer communication, allowing for more design and investment flexibility.

New information systems can also influence the relationship between consumers and designers. Advanced systems can allow for a computer-based "tour" of building interiors and exteriors, serving as the basis for a computer-based structural analysis, a study of lighting, or an assessment of energy consumption. Japanese housing producers sell factory built homes through retail outlets and "show rooms," much like automobile dealerships in downtown locations. Some make use of computer assisted displays that permit customers to design their own products.[116] While there has not been extensive use of such technology in the United States, important suppliers of housing products have begun to experiment with new communication technologies. Sears Roebuck & Co. has developed an interactive video system which allows customers to browse through 11,000 types of curtains, blinds, and shutters and to receive decorating tips.[117]

New technologies could reduce the cost of modifying designs while preventing errors in areas unaffected by the change. The risks of trying a new idea would be reduced, because a concept would be transferred to drawings and analyzed without a major investment in time or money. Automated design systems coupled with communication systems could facilitate the performance of geographically dispersed teams, allowing clients, architects, engineers, and construction firms to cooperate during the entire implementation process. Computer based technologies could also improve the system of competitive bidding; they might quicken the initial bid application, reduce the uncertainties associated with bidding, and decrease the burdens associated with analysis. Design flexibility is not limited to commercial structures. Prospective homebuyers can now plot their own floor spaces, or compare the appearance of different interior and exterior wall coverings.[118]

If computer assisted design represents the first major revolution in building design, factory production of structures and components is the first in assembly. History is littered with predictions of an end to site construction and the development of an industry that would resemble more conventional manufacturing enterprises,[119] making it easy to be cynical about new claims. However, there have been recent gains in factory-based construction of homes and small commercial structures. Though data sources differ, it appears that as many as one-half of the homes built in the United States today involve at least some factory construction. The other half employ such factory-built components as roof trusses, pre-hung windows and doors, and "wet-cores" (bathroom and kitchen modules).

Assembly techniques for building components have also changed. Various new products are used for insulating materials, floor coverings, exterior wall surfaces, glazing, and floors. Technology has challenged conventional notions about how to provide basic structural support, and optimum design engineering has refined conventional designs. Truss systems can vastly reduce the cost of large, unsupported spans. There is even a possibility that active controls can be installed in structures to adjust for the dynamics of wind loadings. And new adhesive materials have been introduced to facilitate a wide range of construction from decorative paneling to exterior sheathing.

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[116] See *Technology, Trade, and the U.S. Residential Construction Industry*, op. cit., footnote 105, p. 45.

[117] L. Therrien, "Birth of a Salesman: How Video is Revving Up Retailing," *Business Week*, No. 3015, Sept. 7, 1987, p. 109.

[118] U.S. Congress, Office of Technology Assessment, "Technology and the Future of the U.S. Construction Industry—Proceedings of the Panel on Technical Change and the U.S. Building Construction Industry" (Washington, DC: American Institute of Architects Press, 1986).

[119] A 1930s commission organized for President Roosevelt made this claim, which led to significant investment in factory-based home construction by a number of steel and aluminum companies; however, these groups never captured more than 2 percent of the market. President Truman appointed a "housing expeditor," who was to solve the postwar housing shortage through increased factory production. Only a fraction of the goal was achieved. Under the Johnson Administration, George Romney rekindled the dream with "Operation Breakthrough," but this also failed to reach its initial goal. See *Technology, Trade, and the U.S. Residential Construction Industry*, op. cit., footnote 105, pp. 23-26.

Roofing has always necessitated much site labor, and most client complaints result from imperfections in roof assembly. New techniques can produce roofing sections with standing-seam rib panels, joined mechanically by semi-automated equipment. Some U.S. firms have developed a self-propelled "roof runner" to do the mechanical crimping. And over 90 percent of all roof trusses are now built in factories; inexpensive computers can design trusses in all but the smallest facilities. Software serves most common applications, allowing for flexibility in design at no additional cost to the builder.

In addition, concrete structural units can be manufactured in factories and trucked to building sites. Several firms now sell low-rise office buildings, which can be erected in a single day, to clients ranging from retail operations and banks to schools. These structures can be disassembled on the completion of their useful life.

Structures using metal frames and sheathing offer clear opportunities for mechanization, since conventional metal fabrication tools can serve this purpose. Metal-framed housing has never made significant inroads into U.S. markets, due more to market conservatism than to factors of cost or performance. These structures are designed, engineered, and manufactured under computer control. Computers also monitor inventories and material flows, which is critical to an industry where success depends on the ability to deliver products quickly.

Technical change has also affected field erection techniques, particularly for commercial structures. Computer assisted operations have been introduced into equipment for uses ranging from earth-handling to erection, and fully robotic systems will arrive soon. Computer assisted equipment serves to replace people in high-risk situations while improving precision. For example, crane operations account for a significant fraction of all construction accidents. Automated systems can alleviate this factor. Control equipment "remembers" both critical lift heights and swing envelope restrictions.

New technology has not facilitated a large increase in the productivity of renovation or retrofit operations. This work often involves "gut" renovations, where interior work resembles new construction and new materials and assembly techniques. Renovation costs have been reduced by surface wiring for wall mounting, flat-wiring that can run under rugs, modular furniture, modular wall partitions, lighting systems attached to movable partitions, and new types of scaffolding. There is controversy over whether the result is attractive office space.

Diagnostic equipment has been developed to help pinpoint defects in older buildings. Infrared cameras can locate heat leaks, and pressurization devices can indicate sources of unwanted air infiltration. Because facades of certain buildings—especially in older cities like Chicago and New York—have fallen to the street, renovation must now address issues of public health and safety. For example, X-ray, video, and other diagnostic equipment are employed to spot defects; nuclear scanning, capacitance testing, and other techniques are now used to locate sources of roof cladding defects.

It is entirely possible that the forces that reshaped the construction industry abroad will also revolutionize the U.S. construction industry. The construction firm of the future may resemble that of conventional manufacturing industries in terms of method and application of research, product assembly, and worker skill levels. Large firms with a high level of technical sophistication are capturing a larger share of markets in areas that were once the domain of smaller companies, creating an industry with a national rather than regional scope. And technology can alter the seasonal nature of construction employment: "flexible factories" that serve changing markets can replace a "flexible workforce."

TRANSPORTATION[120]

Prospects

Emerging production networks and American lifestyles depend on a flexibile and responsive transportation system, tailored to individuals and comparatively small shipments. These demands have the potential to reshape the network of businesses that provides transportation for U.S. consumers and businesses:

- Personal transportation systems could be rebuilt around personal vehicles, and guideways (highways, and rail lines) could be tailored to provide fast, safe transportation. Pedestrian and mass transportation systems could play small but critical roles in high density areas. Freight movement could exploit the power of new communication systems to ensure fast, reliable delivery of comparatively small shipments.
- Congestion and a deteriorating highway infrastructure could limit growth of mobility and limit the growth of dynamic production networks based on "just in time" integration of large and small producers, in different parts of the country or different parts of a given metropolitan area. Destructive competition could lead to a decline in safety.

Public regulation of transportation has sharply declined in the past decade. Government influence over the future structure of the system can be critical. Public decisions about research priorities, construction of new highways and other facilities, and regulation of safety will play a decisive role.

Structure and Performance

The production recipe for the transportation system involves a complex amalgam of private and public spending. With the exception of rail, most guideways are purchased at public expense (primarily through user fees) while equipment is privately owned. Moreover, a significant amount of transportation is purchased as an intermediate good by businesses, rather than being purchased directly by individuals or the government. The purchases involved in transportation include:

- equipment—automobiles, trucks, railroad rolling stock, and aircraft (the manufacture of vehicles falls almost entirely into the High Wage Manufacturing sector, and is discussed in the final section of this chapter);
- guideways (the businesses that build these facilities are included with the Construction sector, and are addressed in the Construction analysis of the Housing discussion);
- control and communication networks—dispatch systems and air traffic control (some of these are discussed in the section on Personal Business and Communication);
- terminals and transfer facilities—parking spaces, airports, rail yards, ports, harbors, and warehouses;
- vehicle maintenance facilities;
- fuel purchases, insurance, and associated supplies (the production of automobile insurance is also examined as part of Personal Business and Communication); and
- packaging and containers—standardized bulk containers for rail and truck or shipping as well as product packaging (packaging technology is discussed in the section on Food).

The discussion in this chapter will deal primarily with the provision of transportation services.

The network of value-added generated by consumer and government purchases directly related to the Transportation amenity is dominated by transportation services (30 percent), purchases of vehicles (High Wage Manufacturing captures 16 percent), and Natural Resource enterprises providing energy for vehicles and materials needed for vehicle and highway construction (see figure 6-6).

Factors Forcing Change

The Nation's recipe for delivering transportation services is comparatively stable, in part because the enormous capital investment in equipment and guideways makes change difficult. Technology has a com-

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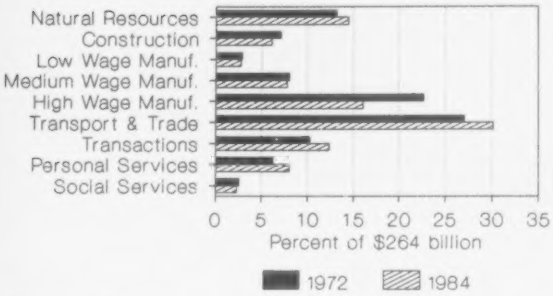
[120] Much of this section is drawn from U.S. Congress, Office of Technology Assessment, "Transportation," sector study, Washington, DC, 1987.

Figure 6-6.-Value-Added To Meet Demand for Transportation ($264 billion* in 1984)



*Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

paratively small direct effect on transportation recipes. Nonetheless, rapid changes in the nature of demand for personal and business transport, the potential for rapid increases in fuel prices, and growing congestion in critical bottleneck areas (such as busy airports and crowded suburban highways) have created significant pressure for change. Public decisions about highway construction, airports, air-traffic control systems, and the implementation of regulations will necessarily play a key role in the performance of the transportation system emerging over the next two decades.

The Nation's transportation system depends almost entirely on liquid fuels—primarily fuels derived from petroleum. There is almost universal agreement that the price of petroleum will rise sharply during the next two decades. Optimists hope that the rise will be gradual enough to allow private markets to make a graceful adjustment to a new fuel source. Others fear that the rise may come rapidly in response to a crisis in the Middle East or elsewhere.

The price of petroleum in the United States now reflects the operation of comparatively free world markets. The United States has opted to use regulations rather than fuel prices as an inducement to increase fuel economy in automobiles. These regulations proved impossible to maintain when low fuel prices gave consumers a message that fuel was inexpensive and plentiful while regulations demanded parsimony. Many other developed nations, however, place a $1 to $2 per-gallon tax on petroleum fuel, giving consumers a strong incentive to find substitutes. This was originally done because driving was taxed as a "luxury" like alcohol and cigarettes; it now reflects the high national cost associated with heavy petroleum dependence that is not included in market-based fuel prices.

Changing regulations in the past decade have begun to reshape the Nation's transportation system. Air, truck, rail, and bus transportation systems were all once heavily controlled by Federal regulation. Most of these regulations have been either eliminated or substantially modified in the past decade. The full impact of these changes has yet to be felt, but they appear to have increased the overall efficiency of transportation in the sense that the new system offers more choice in quality and cost of service. There is, of course, continuing controversy about whether deregulated airlines are safe, whether drivers for small trucking firms are as safe as those working for larger firms, and whether consolidation and mergers occurring throughout the industry will lead to lower prices and more choice or the converse.

The critical issue of licensing truck drivers remains one of State discretion. Concern about safety has led to proposals that more classes of driver licenses be introduced, and that State licensing be either coordinated or replaced by a national framework in cases where driver responsibility is critical. Transportation of hazardous materials is an example.[121]

One trend that deserves special attention is greater use of "intermodalism," in which different transportation modes are combined to provide a transport (rather than road or rail) service in a way that minimizes costs. Examples are the park-and-ride lots that allow commuters to transfer from private autos to a bus or train, joint airfare-car rental discount packages, and the sale of airport-to-downtown limousine service tickets on the aircraft.

Intermediate Demand for Transportation

Business Travel.—As the number of white collar jobs has increased, business demand for the transportation of people has grown more rapidly than that for freight. While statistics are poor, it appears that about one-third of all intra-city travel is for business and therefore must be considered as "intermediate" and not final demand.[122] There are, of course, many ambiguities in this accounting since most people pay for their own trip to work while the employer typically picks up the price of parking (a not inconsiderable expense hidden in the cost of commercial and industrial structures).

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[121] U.S. Congress, Office of Technology Assessment, *Transportation of Hazardous Materials*, OTA-SET-304 (Washington, DC: U.S. Government Printing Office, July 1986).

Since the businesses that require significant personal travel are growing rapidly, personal travel would seem to be a growing part of the "recipe" for American production. On the other hand, modern communications can substitute electronic for personal contact. Telephones, computer communications, and eventually high-quality video conferencing could replace much business travel. But will this occur? The signals are mixed. The introduction of the telephone put more people in contact with one another and actually increased, rather than decreased, the need to travel.[123] Newer forms of communication may have the same effect.

Freight.—Changes in economic structure are reshaping demand for freight services in a variety of ways. Perhaps most fundamentally, the economy is becoming less intensive in its use of materials. The consumption of steel, cement, paper, and a variety of chemicals appears to have peaked. A variety of factors are involved:

- more efficient use of materials in manufacturing,
- a shift toward light-weight materials (e.g., substitution of plastic for steel in automobiles and of light packaging material for metal cans),
- recycling of existing materials,
- development of materials with longer useful lives, and
- a movement toward an economy dependent on high-value information and products with a high value per unit weight[124]

As a result of these changes, freight traffic (measured in tons shipped per dollar of GNP) has fallen by 40 percent since 1950. At the same time, however, bulk commodities are being shipped further. Manufacturing centers appear to have moved away from sources of raw materials, sources of bulk materials close to population centers have been exhausted, and some regions appear to have specialized in the production of raw materials. More than 20 percent of all domestic U.S. energy resources, for example, are now shipped from Alaska. Rapid growth in exports of bulk farm materials and coal have added to demands for long-distance freight movement. Intercity tonnage increased 60 percent between 1950 and 1983 while intercity ton-miles increased 100 percent—the same rate as GNP—implying an increase in average haul length of over 30 percent.

Increasing interest in better inventory control and integration of geographically dispersed production centers has placed a premium on fast, reliable delivery of relatively small shipments. While there may be an upper limit to the tons of material per person that an economy needs to move, there is no apparent limit to the amount of value per pound that can be added by sophisticated production. Increasing the value per unit weight of goods, coupled with production systems that are paying close attention to inventory controls, is requiring higher quality from transportation services.

Demand for freight transport has also changed, as manufacturing in the United States is becoming more geographically dispersed and is moving from urban to suburban and rural areas. Changes in the location of population centers, retail outlets, and production centers have increased the market for relatively short-haul collector/distributor freight shipments within urban areas.

All these effects translate into a growing demand for quality—speed, reliability, and security—and for batch rather than volume shipments. In the past decade, this has resulted in rapid expansion of truck and air shipments at the expense of rail shipment and Great Lakes waterways. Trucks appear to be the vehicle of choice for most high-value shipments. Trucking accounted for 37 percent of total intercity tonnage in 1982, up from 26 percent in 1950. Railroads have countered by introducing containers and vehicles that can operate on both rails and highways, which offer greater flexibility and reliability. While only about 4 million tons of material are shipped by air, air freight grew by a factor of 10 between 1950 and 1982.

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[122] U.S. Department of Commerce, Bureau of Economic Analysis, "Input-Output accounts," *Survey of Current Business*, various issues.

[123] Herbert S. Dordick, "What 'Home Work' Means to Large Organizations, Home Workers and Home Builders," *Land Development Studies*, vol. 3, 1986; and I. de Sola Pool (ed.), *The Social Impact of the Telephone* (Cambridge, MA: The MIT Press, 1977).

[124] R.D. Larson, M.H. Ross, and R.H. Williams, "Beyond the Era of Materials," *Scientific American*, vol. 254, No. 6, June 1986, p. 34.

Measuring Productivity

Given the qualitative changes occurring in the nature of demand for transportation, it is increasingly difficult to develop an acceptable measure of performance. Measured in terms of the average price of a ton-mile and a passenger-mile, the Nation's transportation system has shown steady improvement. Some of the price reductions may be the result of the changing mix of services demanded, since the price of public transportation and freight services has grown more rapidly than average. Such price indices can be misleading, however, because they span a period when deregulation radically changed the price structure of many transportation services—particularly air fares, as survey techniques may not accurately reflect the real impact of discount fare structures that have become the norm rather than the exception.

Price per pound is, however, only one element of service competition. If efficiency is measured in terms of average speed, the record is not particularly distinguished. Although highway speed restrictions limit trucking performance, problems of track quality and yard efficiencies have limited the average speed of the U.S. rail system.

Increased competition has made the U.S. transportation system more flexible and dynamic. Some of this flexibility has been achieved at the cost of stable, well paid jobs in the industry (see ch. 12). At the same time, outmoded work rules continue to present problems in established industries like railroads. A journey from Chicago to Los Angeles, for example, can require nearly 20 crew changes. Real efficiency improvements will require innovations in labor-management relations as well as new technology.

The indications are that the U.S. freight transportation system can adjust to changing economic conditions, patterns of demand, and input costs more rapidly than in the past. Some of this new flexibility has been achieved by improved communication and computation technology, equipment changes, and new management strategies made possible by deregulation.

Scale and Scope.—Major changes have occurred in the way that industry firms are organized. The deregulation of air travel following the 1978 Airline Deregulation Act has introduced much confusion as the industry struggles to rebuild itself around a new set of rules. There has been much controversy over the extent to which regulation of safety can be separated from regulation of fares and other features of air travel. The efficiency of "hub" systems seems to have been revealed by new regulatory freedom. The new public rule scheme has also revealed the subsidies inherent in regulation, resulting in higher fares to certain locations (typically smaller towns) and lower fares on heavily traveled routes.

Nontheless, shadows of former regulations are still visible in the air transport system:

- The two airline reservation systems whose development was, in effect, subsidized by regulated fares on all flights are privately owned. Development of a competing system is virtually impossible.
- Many airports are largely owned by one or two carriers. American Airlines controls 63 percent of the traffic from Dallas-Fort Worth International Airport. Northwest controls 81 percent of the flights from Minneapolis-St Paul and 64 percent of the flights leaving Detroit. U.S. Air controls 84 percent of the Pittsburgh market.[125]
- Landing and takeoff rights during peak times at congested airports are not available on the open market. They can be bought only by purchasing an entire airline.
- A series of mergers and acquisitions has significantly increased the concentration of the airline industry. In 1986, 12 major carriers controlled 85.5 percent of air travel while in September 1987, 8 airlines account for 94 percent.[126]

All of this suggests that deregulation may result in less competition and not more.

Deregulation has had a major impact on the rail industry as well. Many feel that the rule changes helped improve efficiency by concentrating traffic on a smaller number of routes, and by permitting greater economies of scale in functions such as billing, invoicing, and routine management.[127] The Railroad Revitalization and Recovery Act of 1976 and the Staggers Rail Act of 1980 liberalized merger policy and made it easier for railroads to demonstrate unprofitability of a line. The result was a dramatic decrease in the number of miles in the system.

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[125] A. Salpukas, "Air Fare Increase Worry Regulators," *The New York Times*, Sept. 9, 1987, p. D5.

[126] Ibid.

A new element of flexibility in pricing was also introduced by deregulation. While average annual rail freight costs outstripped the overall U.S. GNP price index (or deflator) between 1975 and 1982, growth in freight costs since that time has been less than two-thirds that of GNP.[128] Special prices can now be arranged to reduce the need for empty cars in backshipment. For example, Union Pacific has introduced a reduced rate for hauling fertilizer for Cargill north along the Mississippi in grain cars that would otherwise have traveled empty. The rates are designed to be competitive with barges. Such a strategy would have been virtually impossible without regulatory changes.

The Motor Carrier Act of 1980 greatly eased entry into trucking, and relaxed regulations governing rates and service offerings. The effect on the industry was dramatic. The number of trucking firms increased from 18,000 in 1980 to nearly 30,000 in 1983. Profit margins and returns on equity have fallen rapidly; indeed, the rapid rise in the number of firms has been partially offset by the nearly 6,500 business failures occurring since 1978.[129] While average profitability for the industry has fallen below traditional levels, profits have improved for some specialized carriers, particularly larger firms.[130]

The market for trucking seems to be bifurcating. Economies of scale and scope appear important in the "less-than-truckload" (LTL) market, and this business is increasingly dominated by comparatively few carriers—the top 10 LTL shippers control 60 percent of all U.S. LTL shipments and 90 percent of all LTL profits.[131] These economies result in part because firms large enough to operate sophisticated, computer-based communication and dispatch systems have more flexibility and operate more economically. On the other hand, there appears to be cut-throat competition among small shippers and owner-operators in the truckload market; most of the industry turnover has occurred among truckload shippers.[132]

A competitive market may favor larger shippers who have greater market power, higher volume, and more continuity. Some case studies indicate that small firms lost ground in service and rates in Minnesota and Florida.[133] On the other hand, volume discounts are generally not large, and can be given to brokers and shippers' agents who can pass the savings through to smaller shippers.

The problem of "captive shippers" also appears to have grown since deregulation. A growing fraction of bulk shippers are tied to a single railroad for at least a part of their route. This presents real dangers of monopoly pricing and reduces incentives for improvements.[134]

Geographic Effects.—Small cities with air fares implicitly subsidized by more lucrative air routes have faced increasing prices or less frequent air service. Bus service and short-haul air service has filled many of the gaps.

While statistics are not available to confirm the point, it appears that deregulation has not led to a decline in the freight transportation services available for most communities; service from small shippers actually appears to have improved. Competition opened a number of options for remote shippers and often reduced prices. On the other hand, over 240 locations had their scheduled bus service reduced by more than 50 percent in the three months following bus deregulation in 1982 (the Bus Regulatory Reform Act).

New Technologies and System Integration

A number of trends in the Nation's transportation system are almost certain to continue for a generation. They include:

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[127] "Transportation," op. cit., footnote 120.

[128] U.S. Bureau of the Census, *Statistical Abstract of the United States: 1987* (107th ed.), Washington, DC, 1987, table 699, p. 1053.

[129] Chris Welles, "Is Deregulation Working?" *Business Week*, No. 2078, Dec. 22, 1986, p. 52.

[130] W. Legg, *Financial Analysis of the Motor Carrier Industry, 1985* (Baltimore, MD: Alex Brown, 1986).

[131] Chris Welles, op. cit., footnote 129.

[132] Ibid.

[133] "Transportation," op. cit., footnote 120.

[134] See Mary H. Cooper, "Economic Deregulation," *Congressional Quarterly's Editorial Research Reports*, vol. 2, No. 3, July 24, 1987; Theodore Keeler, *Railroads, Freight and Public Policy* (Washington DC: The Brookings Institution, 1983).

- increasing geographic integration of production within the United States;
- increasing demand for fast, reliable shipments of relatively small batches;
- no significant growth in demand for commodity shipments; and
- continued increases in energy efficiency and labor productivity in rail and air transport.

Personal Travel

The key question for the future of business travel is whether new forms of communication will substitute for physical presence. The answer depends more on psychological attitudes than economics, since it is less expensive to use the telephone than to travel. It is difficult to explain why the physical presence of another individual is felt to be critical to certain kinds of discussions. The need to read gestures, expressions, and other nonverbal communications must have deep psychological roots. Activities that require sensitive discussions, such as personnel evaluations, student tutorials, or delicate contract negotiations, appear to require physical presence while contact such as the exchange of routine business information, is acceptably conducted by mail or telephone. There are, on the other hand, situations where individuals prefer to avoid the "presence" of another individual, prefering the relative anonymity of mail or a message service.[135] The range of alternatives between meetings and mail will continue to increase—the result of new communication technologies that can create a series of "niche" markets offering different levels of contact.

Unfortunately, little is known about the demand for these kinds of services. Such information may develop only after the technology has been in place long enough for society to adjust to its capabilities. It took a generation for individuals to feel comfortable with the telephone.

A number of studies of office location have examined the reasons behind decisions to locate offices in city centers.[136] According to some observers, the need for physical presence in communication is highest for headquarters operations and lowest for back offices that undertake functions like billing and payroll.

Aircraft efficiency has been improved, through both increased load factors and the addition of highly efficient wide-bodied jet aircraft. The gains following energy price increases were dramatic. Commercial aircraft achieved 17 passenger miles per gallon in 1973 and approximately 30 in 1986.[137] The new wide-bodied jets are capable of significant improvements; the Boeing 757 averaged 40 passenger miles per gallon in 1985, and the 767 averaged just over 35 in 1984.[138] Improved air traffic control can also reduce fuel use, by optimizing descent and climbout procedures and by reducing delays. In 1986, the Airline Transport Association estimated that $2 billion in operating costs were lost due to landing and take-off delays resulting from air traffic control problems. These costs do not include the value of the 1 million passenger hours per year lost due to the delays.[139]

Video conferences have been on the horizon since the 1960s, but their cost (still about $1,000 per hour for a coast-to-coast communication) has been prohibitive. In addition, the conferences can usually only be held in specialized facilities. Few individuals value the characteristic of talking to a moving image enough to pay much for the privilege.[140] A significant market could appear if the price of video transmission was drastically reduced and the process made more convenient; 84 percent of Fortune 500 companies have either installed a videoconference facility or plan to do so in the near future. There were 575 installed teleconferencing rooms in place in 1981—4,000 may now be in place.[141]

Freight

The costs and system-wide performance of the transportation system have been improved by a variety of new technologies, many of which were encouraged by changes in regulation. Railroads have been able to achieve significant cost reductions through the use of integral "unit trains" for coal, farm products, phosphates, and other chemicals. Performance was further improved using more specialized cars, consolidated yards, mechanized "hump" yards, and weigh-in-motion systems. The integral trains can move more quickly through yards and loading facilities. The "tare," or empty weight of freight cars, has been reduced through greater use of aluminum. A variety of improvements in trucks—center sills, load dumping systems, drawbars, couplers, wheel slip controls, and multiple unit controls—have improved system performance. Automated sensors now inspect for wheel cracks, and car identification is facilitated with bar-coding. Computer-based dispatching, scheduling, and control systems can improve reliability and timeliness.

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[135] R. Johansen, J. Vallee, and K. Spangler, *Electronic Meetings: Technical Alternatives and Social Choices* (Reading, MA: Addison Wesley, 1979).

[136] See J. Thomas Black et al. (eds.), *The Changing Office Workplace* (Washington, DC: The Urban Land Institute, 1986).

[137] Unpublished data provided by the Federal Aviation Administration.

[138] Ibid.

[139] Airline Transport Association, "Discount Fares Save Airline Passengers $3 billion in 1986," press release, Washington, DC, 1987.

[140] R. Johansen, J. Vallee, and K. Spangler, op. cit., footnote 138; and A. Reid, "Comparing Telephone with Face-to-Face Contact," in I. de Sola Pool (ed.), op. cit., footnote 123, pp. 386-415.

[141] For more on recent developments in teleconferencing by U.S. businesses, see *Fortune*, Aug. 5, 1985, p. 63, and May 2, 1983, p. 295.

The efficiencies of bulk truck hauling have been improved largely through a steady increase in the size and weight of trucks permitted on the highways. In 1974, Congress raised maximum permissible gross vehicle weight on the interstate highway system from 73,280 pounds to 80,000 pounds, though States were allowed to retain lower, "grandfathered" weight limits. The Surface Transportation Act of 1982 made Federal standards preempt State limitations on truck sizes and permitted double trailers on all interstates. These changes may have increased labor productivity in freight transport along some corridors, but the trade-offs remain highly controversial.

The efficiency of barge traffic has also improved due to economies of scale. There has been a steady growth in the size of barges and Great Lakes freighters, made possible by lock enlargements funded primarily by the Federal government. Specialized barges have been introduced that permit high maneuverability in congested areas like the upper Mississippi River.

Pipelines offer great economies for bulk movement. New, larger diameter pipes are now possible because of new technologies. The 36″-diameter Alaska oil pipeline is an example. The performance of pipelines is further improved using better compression systems, pumping systems, and sensors tied to computers that increase effective capacity.

A variety of innovations has improved the system for moving standardized containers from ships to specialized flat-cars and trucks. Entire truck trailers are also carried on freight cars. The transfer of containers is being steadily improved with specialized terminals, automated loading systems, and standardization.

Another class of innovation helps different branches of transportation offer a joint service—intermodalism. For example, the Railroader and Railmaster systems use vehicles with both rubber and metal wheels that can operate on either rails or highways. The vehicles are about 1,500 pounds heavier than standard truck trailers, but are much lighter than standard rail cars. The small performance sacrifice in relatively short highway hauls is more than offset by the advantages offered when these vehicles are used on rails.

Specialized truck dispatching firms have sprung up to provide coordination and status information on material being trucked within the large, fragmented network of intramodel and intermodel carriers. This service would not have been possible without the widespread implementation of computers necessary for controlling, tracking, and scheduling.[142] Only through such a system can the small truckers compete on a nationwide basis with the large corporations. Information services have, as a result, become a critical part of the production recipe for freight transport.

Energy price increases during the 1970s led to a variety of innovations in the transportation system. If the transportation system of 1981 had operated with 1974 energy efficiency, fuel consumption would have been 15.3 percent higher. But energy efficiency is affected as much by the choice of transportation mode and system efficiency as it is by the performance of vehicles. The shift from rail to truck transport, for example, significantly reduced the energy efficiency of the system, since rail transport is three to four times more energy efficient than trucking.

A variety of technical improvements can improve the energy efficiency of freight transport. In trucks, use of radial tires, aerodynamic body shapes (including the now familiar flanges on the cab roofs of many intercity trucks), low-weight materials, and diesel engines can improve energy efficiency. Further improvements include the use of both double-wide tires and engine additions taking advantage of exhaust energy. The average efficiency of trucks can probably be improved by at least 30 percent using technology now on the shelf.

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[142] Thomas S. Gray, "The Effects of Trucking Deregulation on the U.S. Economy: 1980-1985," presented at the Third Creativity, Innovation, and Entrepreneurship Symposium, Framington, MA, May 1986.

It offends common sense to believe that a system using a single person to move a truck trailer across the country can compete with a system using two people to move hundreds of trailers via rail, and rail enjoys markets for commodity and container shipments greater than 600 miles. Trucks tend to compete in long-haul markets primarily when high quality (e.g., timely) service is required or when rail service is not otherwise adequate. Some analysts believe that railroads can never cover the real opportunity costs of their real estate and operating costs carrying anything but commodities hauled on relatively high density routes. It may well be that rail lines and rail yards are a poor use of a unique resource: long rights of way extending into the hearts of virtually every major city in the United States.

To some extent, of course, the balance between rail and trucking will be a public and not a private decision. Rail lines must be maintained entirely by private funds, while some of the cost of public highways is subsidized by taxpayers rather than user fees.

CLOTHING AND PERSONAL CARE[143]

The system of businesses that combine to bring clothing to American markets provides a particularly clear example of the way changes in the warp and the weft of business networks can affect the costs and quality of products delivered, as well as the fate of individual industries that form parts of the network. This discussion will cover the network of businesses that convert fiber to finished apparel offered for retail sale. Clothing and related products represents the bulk of the economic activity in this amenity group.

Prospects

The apparel production system could follow one of several radically different paths during the next two decades:

- The industry could be transformed by technology and innovative management strategies. It could develop an ability to respond quickly to emerging tastes and new developments in production. It could rely heavily on skilled labor and programmable equipment instead of large numbers of low-paid workers. It could tie producers and retail operations together in a tightly integrated network. An ability to tailor products to specific tastes and sizes without significant increases in price would, in effect, complete a cycle that began when the industrial revolution replaced tailor-made apparel with mass production.
- The manufacturing part of the network could be gutted by imports, leaving a domestic industry consisting primarily of transportation, wholesale, and retail operations. It is likely that a small fashion industry would survive and that domestic producers of high volume commodities (like bed sheets) would continue, although the equipment to produce the materials might be imported. Markets for industrial fabrics could be tied heavily to the fate of manufacturing elsewhere in the economy. Without enforcement of wage and hour regulations, there could be rapid growth of "underground assembly" through employment of illegal aliens at subminimum wages.

There may be no middle ground between these scenarios. Given the pace of change in global textile and apparel production, the direction that the U.S. industry will take should soon become clear. At present, signs can be read that point in both directions. The makers of textile machinery in the United States have failed to keep pace with the world state-of the-art. Imports are cutting deeply into domestic apparel businesses. A decline in these industries cuts deeply into prospects for growth in textile and fiber production.

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[143] Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, *The U.S. Textile and Apparel Industry: A Revolution in Progress—Special Report*, OTA-TET-332 (Washington, DC: U.S. Government Printing Office, April 1987).

On the other hand, there has been active movement in the development of tightly integrated production networks, use of flexible production equipment by textile firms (though much of it is purchased from foreign suppliers), and a renaissance in the development of technology for apparel assembly.

With the exception of comparatively heavy trade protection, the rules governing the domestic operation of textile and apparel production are almost entirely those of freely operating markets. Structural changes in this ancient business, however, can be heavily influenced by custom, and tradition. Public support for research has been minimal, but Federal regulations may have inadvertantly had a major effect on industry structure through rules restricting worker exposure to fibers that caused "brown lung." These rules may have played a critical role in stimulating private investment in new, highly productive textile equipment.[144]

Many of these basic rules are in a state of flux. A small Federal investment in new apparel production equipment has proven highly successful. Disparate elements of textile and apparel networks have formed a new series of trade councils to develop standards, communication protocols, and universal product codes.

Structure and Performance

The production and sale of clothing has been dividied into sharply defined operations for generations. Firms that produce man-made or natural fibers supply material to yarn producers, which in turn sell to weaving or knitting facilities. There has also been rapid growth in production of nonwoven fabrics like felt or medical gowns. Fabric is sold to a finisher and then to a garment manufacturer. There, jobbers oversee the movement of products from one processor to another, supplying a finished product to cutters or retailers and maintaining product supplies for spot markets.

The cultures of each of these sectors are different, and almost tribal. Producers of man-made fibers are typically enormous, sophisticated chemical industries like E.I. du Pont de Nemours & Co. Textile production typically occurs in the southeastern United States, in comparatively small businesses often owned by old families. Apparel production is generally an elaborate network of small businesses in the northeast, and more recently by networks of firms using inexpensive American and Mexican workers in southern California. Retail merchants are almost a completely independent "tribe." Many rely heavily on foreign supply, and their interests may diverge sharply from many domestic manufacturers.

While there has been some horizontal and vertical integration, movement has been slow and uneven. Distinct patterns are difficult to identify. In some areas, a period of expansion and mergers was reversed when firms that had diversified returned to narrower specialties. Some concentration has occured in cotton weaving and man-made fiber weaving—the two largest sectors of the textile industry. In the early 1950s the leaders of the textile industry, particularly Burlington Industries and Milliken, moved to vertically integrate the textile product from fiber to finishing; apparel production, however, remains highly competitive and fragmented. Of the more than 200 apparel companies in the United States, less than 1 percent have sales over $100 million per year. While there has been some vertical integration in apparel retailing, most efforts to combine functions have proven unsuccessful. The 1980s saw growth in both large "discount" and relatively small and expensive outlets.

The system that starts with raw materials and ends with apparel offered for sale in retail stores involves virtually every part of the economy. In 1984, only about 17 percent of value-added generated by spending on the Clothing and Personal Care amenity ended up in businesses directly associated with the production of cloth or apparel. Nearly 40 percent appeared as value-added in transportation, wholesale, or retail activity; 13 percent wound up in the hands of transactional businesses (see figure 6-7).

New Technologies and System Integration

Technologies are improving both individual steps in the process used to convert fiber into retail products, and the efficiency of the overall system.

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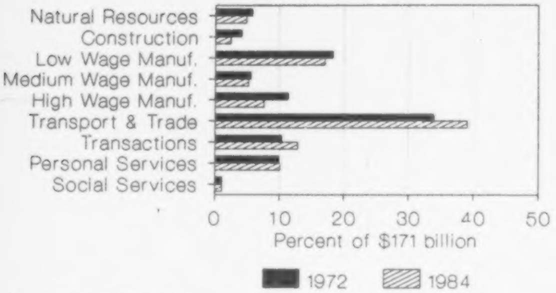
[144] Ruth Ruttenberg, "Compliance with the OSHA Cotton Dust Rule: The Role of Productivity Improving Technology," contract report prepared for the Office of Technology Assessment, March 1983.

Figure 6-7.-Value-Added To Meet Demand for Clothing and Personal Care ($171 billion* in 1984)



*Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

Technical improvements in individual processes include:

- the substitution of synthetic for natural fibers, and an increase in the strength and consistent quality of yarns of all types;
- the introduction of programmable, "shuttle-less" looms and other devices that improve the efficiency of winding and weaving, and of new equipment for producing non-woven fabric;
- computer-assisted garment design;
- numerically directed cutters, including laser cutters, that reduce waste when patterns are cut from cloth and make it possible to produce comparatively small batches of patterns economically;
- automatic sewing systems that can assemble components (like sleeves or trouser legs) using robotic handlers;
- price code scanners that enable retailers to improve inventory control and reordering.

While each of these innovations can, and have, increased productivity in individual businesses, their most important contribution may appear in the way they can be tied together to build a system for delivering apparel to consumers that is more efficient *taken as a whole*.

Improved information flows and responsive batch production are key to what the industry calls a "Quick Response" strategy. The key is holding inventories low and avoiding overstocking while still ensuring that retailers stock what customers want to buy. Accomplishing this will require fundamental changes in the way information flows between the different components of the fiber-textile-apparel-retail chain, and an associated revolution in the style of production. In many ways, the institutional difficulties that must be confronted in implementing such a system pose a greater barrier than the technical problems.

Efficient transportation will also play a key role. Currently, it can take up to 2 months for a product to get from an apparel plant to the sales floor. Initial experiments with Quick Response have shortened this time span considerably, using United Parcel Service for rapid deliveries.[145] Textile suppliers are now able to communicate with large apparel companies with such precision that apparel firms can obtain reliable information about the time and size of delivery, as well as the color and location of fabric within a truck. This permits apparel producers to integrate deliveries closely into their plans, and allows them to avoid costly and lengthy inventories of materials delivered. The Levi Strauss Co. estimates that their new communication system *by itself* saves as much as 10 cents per square yard of material.[146]

The system-wide productivity gains made possible by new communication technologies and flexible production technologies are difficult to measure using conventional methods. There is a certain irony in this, since the consumer obviously measures the performance directly in the price and characteristics of products offered for sale. The dilemma of measurement lies partly in the fact that the productivity of individual businesses may actually appear to *decline* while the productivity of the system as a whole increases. It is possible to describe the areas where system-wide benefits can be expected even when it is difficult to develop precise measurements:

- The enormous inventories carried by textile mills, apparel manufacturers, and retailers can be reduced. On average, it takes roughly 65 weeks for fiber to move from a manufacturing plant to the customer's hand. The material is in processing for only 15 out of these 65 weeks; the remaining 50 weeks are spent in inventory.[147] The cost of this inventory alone represents

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[145] Kurt Salmon Associates, Inc., "Crafted With Pride in U.S.A. Council, Inc., Quick Response Program Report," June 11, 1986.

[146] R.E. Cotton, "QR's Bottom Line," *Apparel Industry Magazine*, July 1986, pp. 26-31.

[147] Sig Scheier, "QR to Consumer Demand Vital, Hinerfeld Warns," *Daily News Record*, Oct. 9, 1985, p. 11.

6.4 percent of retail sales. With good management, it should be possible to reduce inventories by 25 to 50 percent.[148] Proper inventory control can increase sales per square foot, ensuring that the assortment on the selling floor matches proven market demand for styles, colors, and sizes.

- It should be possible to reduce incidents of forced markdowns that result from orders for goods that fail to sell as expected. Forced markdowns have grown by 50 percent during the past decade, and the National Mass Retail Institute estimates that total losses may be as high as 15 percent of retail sales.[149] Forecasting failures are due in large part to the long, 65 week cycle (requiring that most initial orders for seasonal products be placed more than a year before the products are sold). With Quick Response it may be possible to reduce initial order times to 2 or 3 months, and reorder cycle times to a few weeks. Accordingly, the need for long range, imprecise forecasting is greatly reduced.
- Tightly integrated networks can result in cost savings in situations where business is lost because a customer cannot find apparel in the desired style or size when the store is out of stock. Quick Response systems permit smaller initial orders, allowing stores to reorder more of a product that proves popular. The product can then be in stock at full price during the selling season.

  Estimating the magnitude of "stock out" losses is a difficult task, since many consumers who fail to find what they want simply leave a retail store without registering their disappointment. Industry estimates suggest that losses from stockouts are about 8 percent of apparel sales,[150] though field experiments with Quick Response systems suggest that this may be an underestimate. Quick Response reordering systems for sales of basic men's slacks have increased inventory turnover at the astonishing rate of 30 percent, with a comparable increase in gross margins on inventory.[151] A stock count in an experimental installation indicated that while 29 percent of items checked were out of stock before the program began, only 17 percent were out of stock after the Quick Response system was initiated. Retail stores can offer a greater variety of products without a significant increase in inventory through the ability to replenish stocks quickly.
- Responsive networks can also reduce costs and paperwork associated with such overhead operations as billing, invoicing, and inventory controls. Improved information flows and standardized reporting systems can greatly reduce handling and processing costs, such as quality control audits, hanging and premarking of merchandise, and time spent handling and counting deliveries. Perhaps most importantly, four networks that link different parts of the fiber-to-finished product chain more effectively have been created within the last 2 years: the Fabric and Supplier Linkage Council (FASLINC), the Textile and Apparel Linkage Council (TALC), the Sundries and Apparel Findings Council (SAFLINC), and The Voluntary Interindustry Communications Standards (VICS).
- Finally, productivity gains can be realized within the apparel production facility through the use of off-the-shelf equipment, and better management practices can facilitate integration with the overall system. Moving away from the "progressive bundle" system—a process driven by repetition of standardized tasks, which may have been cost-effective in an environment where response time and inventory control was not critical—to a modern "unit production" system can reduce processing times of 4 to 6 weeks to 1 or 2 days.[152] Computer-controlled cutting techniques can reduce material losses by 2 to 3 percent and can take 1 to 2 weeks out of planning, while reducing the number of parts that are cut simultaneously by 30 to 50 percent.[153]

A conservative estimate of the savings that can be realized from a relatively straightforward implementation of Quick Response technologies indicates that the industry could have saved $12.5 billion in 1984.[154] The cost of apparel could be reduced by one-eighth. These savings are realized by the system acting as a whole, and would not be possible through improvements occurring only in component businesses.

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[148] Robert M. Frazier, "Quick Response," presentation made at DUPAATCH, Sept. 13, 1985.

[149] Ibid.

[150] Ibid.

[151] "Quick Response Pilot Program Update," *Crafted With Pride*, Jan. 1987.

[152] R.E. Cotton, op. cit., footnote 146.

[153] Frazier, op. cit., footnote 148.

[154] Peter N. Butenhoff, "U.S. Apparel Competitiveness," paper presented to OTA by E.I. du Pont de Nemours & Co., June 1986.

Most of the savings result from better matching of production to patterns of consumer purchasing because it would allow re-ordering popular items. Inventory costs could be reduced or merchants could maintain a wider selection of items by simply keeping fewer of each style and size in stock at any given time. All of this, of course, depends on close integration of all parts of the design and planning cycle. It requires flexibility in the production of cloth, flexibility in apparel assembly, and flexibility in the transportation network. It also requires relatively short-batch runs.

Where could the technology lead? There appears to be no technical reason why the planning/production cycle could not be reduced to a few days for a wide range of fabrics and designs. Computer displays capable of combining real images of an individual with a synthetic image of different kinds of clothing are already in experimental use in expensive retail outlets. In principle, these systems could be combined with a file maintained on the individual's measurements, producing clothing tailor-made to individual specifications. Assuming rapid delivery services, the garment could be available in 2 to 3 days.

Highly responsive networks are likely to be built largely of comparatively small establishments connected together by a well managed communication and transportation system. It is not at all obvious that these systems would operate more or less efficiently given greater horizontal or vertical integration of management. The standards, agreed protocols, and flexible contracting arrangements may well be preferred to a formal bureaucratic management scheme. A considerable amount of experimentation will be needed before a preferred management strategy emerges.

EDUCATION[155]

Prospects

The Nation's educational enterprises appear to be on the edge of a major reform. There may be no area where changing patterns of demand and the challenges of new technology are creating greater pressure for change. Real economic growth depends as never before on the skills of people in a wide range of occupations. The essential elements of flexibility and adaptability depend not only on knowledge of a particular skill, but on the ability to identify opportunities, to work together, and to acquire new skills efficiently. At the same time, new technology makes it possible to think about major changes in the productivity of learning. Technology has created an unprecedented power to bring practical problems into the classroom environment, adapt instruction to individual needs, and integrate teaching and learning into the work environment so that information and instruction is available when and where it is most essential.

Taken together, the need for change and the power of the new technology can reshape the way instruction is delivered, where it is delivered, and when it is delivered in a person's career. As in all of the other cases examined in this analysis, the network of activities that produce education in the United States are unlikely to show real productivity gains unless basic changes are made in the way the system operates as a whole.

The choices in education are particularly critical and stark:

- A system could be developed that makes learning more efficient and more fun, and that allows teachers to spend more time as tutors and coaches and less in routine tasks. Education could be tailored to individual styles of learning and adapted to strengths and weaknesses in a person's talents and background. Instruction could be available throughout a person's career, empowering individuals to adapt and grow in a dynamic economy.
- A system could be developed that would lead to greater centralization, mechanical and imper-

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[155] Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Education," sector study, Washington, DC, 1987.

sonal instruction, and uniformity imposed by a perception of scale economies. National regulations could choke individualism, and the dominance of a small number of product suppliers could limit real choice and flexibility. Rigid control could be maintained over a student's course of instruction.

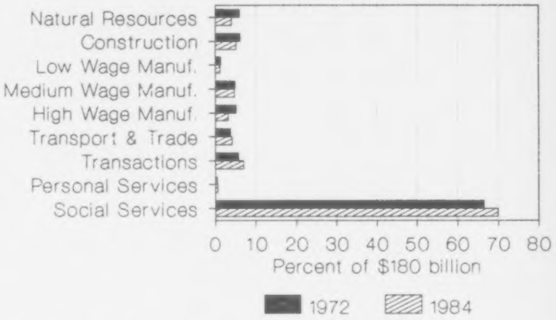
Increased use of capital equipment could lead to major changes in the structure of the Nation's educational system. The process of education could become separated into more differentiated components, coming to resemble other information-intensive enterprises. The development and maintenance of hardware and software for education and training could become an important specialty, and a variety of other specialties could develop. The size and location of institutions could change if technology allows decentralization without sacrificing quality. Instructional activities could be integrated more formally into all business enterprises.

Unlike many other production networks, the future structure of the Nation's educational establishment is primarily the responsibility of public decisions. Some way must be found to combine the need for enterprise and diversity with the need to find resources adequate to the major development efforts that will be needed.

Structure and Performance

The network of operations leading to educational services remains astonishingly unchanged by the forces that have reshaped other parts of the economy engaged in the transfer of information. Personnel costs—primarily for teachers—and the cost of buying and operating buildings constitute about three-quarters of all costs related to business activity associated with the Education amenity (see figure 6-8).

Figure 6-8.-Value-Added To Meet Demand for Education ($180 billion* in 1984)



*Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

Intermediate Demand for Education

The value of a well-educated and well-trained work force is probably the most important input purchased by most businesses, but this input is virtually impossible to measure.[156] During the 1970s, when comparatively well educated members of the baby boom generation were entering the work force and replacing people with lower levels of education, there was some speculation that America had overinvested in education. This argument held that education served primarily to help get preference in hiring but did little to actually contribute to performance once on the job.[157] Given the problems of measurement, such disputes are difficult to resolve with precision. Recent data demonstrate strong links between education, income, and an ability to avoid unemployment (see ch. 11).

American businesses are making heavy investments in education. The total cost of corporate training is probably in the range of $30 billion to $200 billion (see notes to table 3-26). Precise levels are impossible to gauge, since the vast majority of employee learning comes from watching peers, reading manuals, and other informal routes.[158] Unfortunately, as with investment in research, investment in training is often reduced when it may be needed most—when business cycles turn down.[159]

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[156] Several attempts have been made in this area. Among the first were T.W. Schultz, *Investing in Human Capital* (New York, NY: The Free Press, 1971); G. Becker, *Human Capital* (Chicago, IL: University of Chicago Press, 1975); and T.W. Schultz, *Investing in People: The Economics of Population Quality* (Berkeley, CA: University of California Press, 1981).

[157] I. Berg, *Education and Jobs: The Great Training Robbery* (New York, NY: Prager, 1970); A. Weiss, "A Sorting-Cum Learning Model of Education," *Journal of Political Economy*, June 1983, pp. 420-442; and R.B. Freeman, *The Over-Educated American* (New York, NY: Academic Press, 1976).

[158] One estimate suggests that informal training represents 80 to 90 percent of job related training. See S. Lusterman, *Trends in Corporate Education and Training* (New York, NY: The Conference Board, 1985).

[159] M. Meyerson and R. Zemsky, *Training's Policies: Public and Private Reinforcement for the American Economy*, (Philadelphia, PA: University of Pennsylvania Press, 1985), cited in F.D. Fisher, "Redefining Training: An American Perspective," presented to the "Computer Assisted Approaches to Training, Foundations of Industry's Future" conference, May 25, 1987, Lugano, Switzerland.

Few firms have any clear view of what their real training costs are. The costs of staff training may be included as general administration expenses, rather than as "training" or "education." Even where training costs are identified separately they may include only teaching and equipment costs, rather than the costs of an employee's time and other factors that may be much greater than training costs measured directly. The life insurance industry was recently astonished to find that it costs an average of $125,000 to place an agent in the field—the Massachusetts Mutual Life Insurance Company for example, pays trainees during the full 2 to 3 years it took them to be self-supporting through commissions even though, on average, only one out of four entrants managed to become an agent.[160]

The Federal government also invests heavily in training. About 20 percent of the active military is either being taught or engaged in teaching.[161] The U.S. Department of Defense spent $13.4 billion on training in 1984, providing the equivalent of 250,000 full-time students. The Office of Personnel Management estimates that more than 500,000 students per year are trained elsewhere in the Federal government (not a full-time equivalent estimate) at a cost of about $371 million, excluding the wages of the employees being instructed.[162]

While the costs of training are difficult to measure, it is even more difficult to measure the losses resulting from inadequate training. There is obviously a high social cost when adults are unemployed or underemployed because of inadequate training.[163] Direct costs are also large. Chrysler Corporation estimates that it saved $1.3 million by training workers about the dangers of hazardous substances in the workplace.[164] Poor training may have been a contributing factor in the Three Mile Island disaster.[165] Nearly one-quarter of Army and Air Force budgets go for maintenance. These two services probably spend as much to maintain as to purchase electronic equipment. Largely because of poor training, between 9 and 32 percent of all person-hours spent in maintenance was wasted (depending on the type of maintenance problem), and between 4 and 43 percent of all parts removed as defective were not defective.[166]

An even greater implied cost of poor training, of course, can result if a company's employees are not able to adapt to new production systems or new management strategies. Defining the kinds of skills needed for this ability poses a tremendous challenge. Without greater effort to define them, however, there is a danger that the Nation's educational system will have difficulty aiming at the proper target. Any system forced to consider productivity gains is guided in powerful ways by what can be measured. A basic grasp of skills in language, mathematics, and science is clearly essential; box 6-B provides a hypothetical list of other qualitative skills likely to be critical for future employment opportunities.

New Technologies and System Integration

A number of new information technologies are being developed with the potential to change the nature of human communication in fundamental ways by vastly reducing the cost of storing, manipulating, and communicating information. It may soon be possible to manipulate images and sounds as easily as the printed word. This means being able to break some of the barriers of abstraction that separate "scholarship" from the world people see, hear, and understand. Modern information technology also has the power to give participants more active control and greater choice without necessarily adding significantly to costs.

These innovations can radically change the performance and structure of the educational system.

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[160] Life Insurance Management Research Association, Hartford, CT, 1986, reported by Jane Curtis, Director of Field Development, Massachusetts Mutual Life Insurance Co., private communication, November 1987.

[161] Sar A. Levitan and Karen Alderman, *Warriors at Work: The Volunteer Armed Forces* (Beverly Hills, CA: Sage, 1977).

[162] *Training Magazine*, October 1984.

[163] See U.S. Congress, Office of Technology Assessment, *Technology and Structural Unemployment: Reemploying Displaced Adults*, OTA-ITE-250 (Washington, DC: U.S. Government Printing Office, February 1986).

[164] R. Neff, "Videos are Starring in More and More Training Programs," *Business Week*, No. 3015, Sept. 7, 1987, p. 108.

[165] The President's Commission on the Accident at Three Mile Island, "The Role of the Managing Utility and its Suppliers," staff report, Washington, DC, October 1979.

[166] J. Orlansky and J. String, "The Performance of Maintenance Technicians on the Job," IDA paper p-1597, Institute for Defense Analysis, Alexandria, VA, 1981.

Box 6-B.—A New Set of Job Skills

Skills of Problem Recognition and Definition:
- —recognizing a problem that is not clearly presented
- —defining the problem in a way that permits clear analysis and action
- —tolerating ambiguity

Handling Evidence:
- —collecting and evaluating evidence
- —working with insufficient information
- —working with excessive information

Analytical Skills:
- —brainstorming
- —hypothesizing counter-arguments
- —using analogies

Skills of Implementation:
- —recognizing the limitation of available resources
- —recognizing the feed-back of a proposed solution to the system
- —the ability to recover from mistakes

Human Relations:
- —negotiation and conflict resolution
- —colaboration in problem solving

Learning Skills:
- —the ability to identify the limits of your own knowledge
- —the ability to ask pertinent questions
- —the ability to penetrate poor documentation
- —the ability to identify sources of information (documents and people)

SOURCE: Based largely on Francis D. Fisher, "Redefining Training: An American Perspective," presented to the "Computer Assisted Approaches to Training, Foundations of Industry's Future" conference, May 25, 1987, Lugano, Switzerland.

The new generation of technologies, built on relatively inexpensive equipment, are qualitatively different from the film strips, television shows, and other techniques that have been used in limited ways to augment instruction in the past. They represent something fundamentally new. In principle, new information technologies can actively engage students or groups of students, and can shape instructional programs to indiosyncratic styles of learning, individual interests, and individual assets and strengths.

The Potential for Change

In order to understand the potential for change in a sector where productivity and structure have been static, it is necessary to begin by demonstrating that real change is attainable. The following discussion identifies several areas where progress is clearly possible.

Improved Understanding of the Learning Process.—There is much room for improvement in what we know about how learning takes place and about the efficiencies of different learning techniques for different people. This is true both for formal classroom instruction and for skills acquired informally at home or on the job. Informal learning on the job can take a variety of forms. It can mean a worker on a shop floor struggling with the documentation for a new machine tool, a secretary puzzling over new word processing software, or an employee in the "back office" of an insurance firm learning how to underwrite a new type of policy. Clearly, sailors, physicians, and carpenters approach problems in different ways. Each profession, however, combines formal knowledge and formal reasoning from abstract principles with experience and a reservoir of anecdotal evidence.

Failure to understand the learning process obviously means that there are few good guidelines for improving its productivity. Most formal training by corporations is practically identical to instruction delivered in standard classroom settings. But a sensitive understanding of learning pathologies is required to teach adults who enter retraining with an enormous variety of backgrounds. The efficiency of instruction is obviously improved where it is possible to discover what people do not know, and why they fail to understand important topics.

The new field of "learning pathology" is beginning to discover why students fail to understand some topics. Analyzing errors made by elementary school students, John Seeley Brown of Xerox found 150 distinguishable patterns of errors in simple subtraction problems. There is obvious merit in finding a way to focus on a student's real problem (perhaps a failure to understand the meaning of the number zero) rather than repeating an entire lesson.

Many basic issues in pedagogy would have needed to be addressed even if new demands had not been placed on the Nation's educational system. New technologies make the issues impossible to avoid.

Research on advanced computer designs may provide some serendipitous help. There are powerful connections between research on human learning and research on productive designs for information technology. The study of "artificial intelligence," for example, addresses basic problems in inference and tries to understand how "experts" think about complex problems. The results of such efforts are likely to influence strategies in teaching before they lead to significant changes in the design of computers.[167]

John Henry Martin's "Writing to Read" program, developed with IBM support, is a basic innovation in pedagogy stimulated in part by an analysis of how best to integrate computers into classrooms.[168] The basic idea is to shrink the distance between the rich tools of spoken language of pre-school children and the limits of written language that are available to students entering kindergarten or first grade. It is done by teaching students to decode spoken words using 44 phonemes, and then asking then to use these codes to write stories that use their entire vocabulary. The computer helps primarily by making it easier for students to form letters and by making the task more fun.

The Ability To Teach Individuals, Not Averages.—Earlier discussions have provided examples of the way modern production equipment makes it easier to serve niche rather than mass markets. The American system of education, however, continues to deliver a relatively uniform level of instruction with a rigidly proscribed conception of what is to be learned.

New technology can help teachers design programs of instruction suited to individual tastes and talents. Some students learn faster from text, some from lectures, some from repetition, and some from visualizations or examples drawn from areas of personal interest. Technology would not, of course, substitute for a good teacher—but it could provide an invaluable tool for helping teachers tailor instruction to the needs and talents of many individual students. This is obviously difficult in a standard classroom setting. It is possible to imagine an "expert system" of the kind available to physicians, designed to diagnose the source of a specific learning problem or to construct a program of instruction most likely to interest a specific student.

Technology also has the potential to monitor the progress of individual students in a way that rivals the attention of an individual tutor. It can ensure that the pace of instruction does not outpace a student's understanding. Using a series of built-in tests, it can ensure that each student has mastered a subject before being forced onward. It can also permit the student to take "curiosity excursions" into areas that may not be of general interest. And it can facilitate a detailed diagnosis of the sources of a student's misunderstanding and habitual errors.

From the student's perspective, the power inherent in new technology means more control over the pace of learning and less repetition of things already understood. It means not being embarrassed to acknowledge what is not understood. It means the freedom to have fun by building a program of instruction around a set of interesting problems. It means the security of building new knowledge on a base of information that is familiar.

The Ability To Simulate.—There is also much to be learned about the role that games play in learning. In traditional societies, where children could see much of the work done by adults, play mimicked life. Skills learned in playing at hunting or at household tasks translated gracefully into the practical world. In contrast, contemporary society places enormous barriers between the world of adults and the world of children. Few children have a clear sense of their parent's work life; classrooms seldom provide good tools for understanding the work environment. In principle, simulations can mix work with instruction and instruction with play in entirely new ways. The interest and entertainment of an interactive spy adventure can be used to teach map reading, geometry, or chemistry.

After centuries without practical alternatives, people have become accustomed to think about communication in terms of words and books. New visual technologies, however, can provide a means of communication that is in many areas more powerful than language. Leaving aside the question of whether language and grammar are an integral part of human intelligence, it is obvious that words in a geography text are a poor substitute for a visit to Brazil and that a flight manual is a poor substitute for a turn at the controls of an F-16. The emerging generation of information technology has been used to create flight simulators capable of producing an experience so faithful to reality that even seasoned pilots are able to benefit. This power to imitate reality can have a helpful role in education.

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[167] W.K. Estes and A. Newell, *Research Briefings, 1983*, briefing panel on Cognitive Science and Artificial Intelligence, Committee on Science, Engineering and Public Policy, National Academy of Sciences (Washington, DC: National Academy Press, 1983).

[168] John Henry Martin, *Writing to Read* (New York, NY: Warner Books, 1986), Alice Kelly and Sophia Kelly, private communication.

Much of modern history is available to us in the form of film or television images and sound recordings. These images and sound recordings are arguably responsible for some of our history. The radio clearly helped Franklin D. Roosevelt gain the presidency and strongly influenced the way he communicated with the public as president. Television helped Ronald Reagan in much the same way. Yet the capacity for managing images (particularly moving images) has never been developed with the same facility as that for sorting and analyzing words on paper. Pictures are a "second class" resource in any library. Technology now emerging can change this status by making it nearly as easy to retrieve, make, and modify images as words. Simulations can also help where student motivation depends on a belief that knowledge will provide power for solving real problems.

Simulations can take a wide variety of forms:

- The Defense Department has a long and successful record of using simulations to train pilots, tank drivers, TOW missile crews, maintenance personnel, and a variety of other specialists.[169]
- Goodyear successfully used simulators to train repair crews in the use of multimeters and oscilloscopes.[170]
- Simulators have been used to train welders who use light-pens instead of welding rods. This equipment can determine such factors as the beginning and ending points of the weld made and whether the simulated rod is moved at the proper rate.
- Medical technicians can be trained to identify tumors on displays of actual Magnetic Resonance Imagery (MRI) or Computer Assisted Tomography (CAT) images. Simulations can reproduce medical emergencies demanding immediate responses and analysis for physicians in emergency rooms.
- Insurance sales personnel can be confronted with a variety of potential customers using video representations of consumer types. The agents' responses are videotaped and played back so that students can judge their own responses and ask for expert advice. This experience is so compelling that many students elect to drop out rather than continue training. There are obvious advantages for both the student and the company if the student's incompatibility with the job is identified early.[171]
- A new data compression technology developed by the David Sarnoff Laboratory allows a student to simulate a walk through the Mayan city of Palenque using data stored on a standard 5" compact disk. The system permits the student to go virtually anywhere at the site, stop, and look around a 360 degree vista. It is possible to take pictures of sites for further study.[172]
- A variety of chemistry laboratory experiments have been simulated using video representations which could be controlled by computer.[173] These simulations are obviously safer than actual experiments.

Communication v. Isolation in the Learning Process.—In the abstract, computer-based instruction often evokes an image of passive, hollow-eyed students staring at flickering screens in great windowless halls, or small cubicles. This would be a disastrous outcome given the desirability of allowing students to learn from each other and work as parts of dynamic groups. While it is obviously possible to use computer-based instruction in nightmarish ways, new instructional technology appears to open opportunities for mixing isolated study with work as a part of a group. It seems possible to use the equipment to improve communication on many levels: between teachers and students, among students, between schools and the body of knowledge and specialized expertise outside of the school system, between schools and parents, and among the teachers within the system.

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[169] J. Orlansky, "The Cost Effectiveness of Military Training," in *Proceedings of the Symposium on the Military Value and Cost-Effectiveness of Training*, NATO headquarters, Defense Research Group on the Defense Applications of Research (DS/A/DR(85)167), Brussels, Belgium, January 1985 (evaluations of the program are reported later in this section).

[170] S. Holzberger, "Goodyear Tire Compares ITC ACTIV With Traditional Training Methods," *The Videodisc Monitor*, March 1987, pp. 14-15.

[171] Jane Curtis, op. cit., footnote 160.

[172] The system was developed with the assistance of the Bank Street College. Mike Tinker, David Sarnoff Laboratory, private communication, December 1987.

[173] One test found no measurable difference between the test results of students working with the computer system alone and students in real laboratories. See S.G. Smith, L.L Jones, and M.L Waugh, "Production and Evaluation of Interactive Videodisc Lessons in Laboratory Instruction," *Journal of Computer-Based Instruction*, vol. 13, No. 4, pp. 117-121, autumn 1986.

Giving students an avenue to participate in different kinds of social groups is an important contribution of the school system.[174] The ability to collaborate with individuals having different kinds of skills and different viewpoints, to perform effectively as part of a heterogeneous society in a variety of circumstances, and to debate effectively about a disputed point are all important skills both on and off the job. The goal may be one of having students "learning around the computer" as opposed to learning with the computer: "when several students work together at a computer display two things happen: learning becomes more of a social activity than in the usual school environment and an impressive amount of peer learning takes place."[175]

The potential for teaching groups has obvious advantages in corporate and government training programs, but documentation is rare. The U.S. Army has found that one of the most valuable uses of its new M-1 tank simulator was the way it permitted a team of tanks to practice working together in difficult tactical situations. It is critical that members of a tank battalion learn to work together, to trust each other, and to adapt quickly in unexpected situations, since group maneuvers are extraordinarily difficult to undertake in the field.

Informal observation suggests that adults can be made more comfortable in reentering a classroom environment if they are paired with another person of similar skills. The partners can help each other, and if baffled are less restrained in asking the instructor a question. They assume that if their confusion is shared, they should not be ashamed.[176]

It is fair to ask whether the new strategies proposed for "learning around a computer" represent an improvement over the existing system. Appearances to the contrary, the standard classroom instructional techniques prove to be highly impersonal. Collaboration is discouraged in virtually all cases—it is often considered "cheating." Companies have complained that formal instruction methods result in students who want to solve problems in isolation, unable to benefit from group discussions.[177]

One observer has found that "88 percent of all instructional time in the high school involves only two methods: telling, lecturing, and questioning the total group and monitoring some form of seatwork."[178] Similarly, about 70 percent of the student's time in elementary school was spent listening to lectures; the figures were 77 percent in junior high and 76 percent in high school. The lectures in this investigation typically presumed student passivity. Barely 5 percent of instructional time was designed to create student anticipation of a need to respond, and when a response was required it was often a simple recall of fact. The overall strategy of interaction was summarized as follows:

> First, the vehicle for teaching and learning is the total group. Second, the teacher is the strategic, pivotal figure in this group. Third, the norms governing the group derive primarily from what is required to maintain the teacher's strategic role. Fourth, the emotional tone is neither harsh and punitive nor warm and joyful; it might be described more accurately as flat.[179]

The passivity just described scarcely portrays a situation characterized by a great deal of communication within the schools themselves, either between students and teachers or among peer groups of students or teachers. There is also is little communication with the world beyond the school door, or between schools and parents. And with the exception of major universities, most teaching material does not reflect recent progress in research. Available mechanisms for upgrading teachers' skills are seldom adequate; textbooks remain the main source of substantive communication with external research, yet texts for courses taught in primary and secondary schools are infrequently revised. School texts in Texas, for example, despite being updated every eight years, have become out-dated in important areas.[180] While universities are designed to forge good links between instructors and advanced research, these links are growing weaker. Some faculty members are forced to take on heavy teaching loads in order to keep college costs down, while others are engaging in proprietary research that cannot be shared with students.

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[174] George Leonard, *Education and Ecstasy* (Berkeley, CA: North Atlantic, 1987).

[175] Margaret Cox, cited in "Education," op. cit., footnote 155.

[176] Virginia Nelms, IBM Corp., private communication, December 1987.

[177] W. Glasser, *Control Theory* (New York, NY: Harper & Row, 1985); and Judith Resnick, "Learning in School and Out," *The Educational Researcher*, vol. 16, No. 9, December 1987.

[178] John I. Goodlad, *A Place Called School* (New York, NY: McGraw Hill, 1984), p. 12.

[179] Ibid.

Improving Productivity

The challenge of measuring productivity in education was discussed at some length in chapter 3. The difficulty results from both an inability to measure net investments in education from the many contributing sources, and an inability to develop acceptable measures of educational quality. Problems of measurement are, if anything, becoming more difficult. The flexible skills now needed by the U.S. work force defy easy documentation.

Many attempts have been made to link student performance to teaching salaries or per-capita spending. Correlations are difficult to establish when adjustments are made to correct for the income and educational levels of families.[181] Students with strong family support for education have tended to do well in virtually all circumstances;[182] strong correlations have also been found between the performance of a teacher's students and subjective evaluations of the teacher made by supervisors.[183]

The failure to find correlations between spending and progress obviously does not mean that greater investment cannot lead to greater results. It does suggest that much remains to be learned about the efficiency of different strategies for teaching and learning.

Against this background, estimates of improvements in educational productivity must be treated with caution. Quantitative estimates of productivity change resulting from new technology are particularly difficult to document because of the poverty of information on experimental programs. Experiments with documented results have typically used primitive computer-based teaching technologies that were available only for short periods of time—none involved the kinds of fundamental reform outlined above. Many systems entering the market have not been well designed or tested. As a result, it is not clear whether tests of effectiveness are measuring the quality of the software or the inherent power of the new technology.

In spite of these limitations, significant improvements in teaching and learning can be documented.[184] An exhaustive survey of Defense Department experience with training is summarized in table 6-5. Information on flight training is well documented because of its long history. The Defense Department has spent over $1.2 billion on flight trainers; the cost of operating a trainer ranges from 2 percent of flight costs for a B-52G to 50 percent for an AH-1s. The amount of savings depends heavily on what is being learned. For some types of training, simulators have proven useless or worse. In other cases, an hour on a trainer was twice as effective as an hour in actual flight.[185] On average, each hour spent on a simulator was equal to 0.48 hours of actual flying experience. The simulator, of course, could provide experiences that would be dangerous or even impossible to rehearse in a real aircraft.

Extensive studies are also available for computer assisted training in maintenance. In 12 of 13 examinations, students trained with a simulator achieved the same or better test scores than those trained with actual equipment. Students using simulators, however, required 20 to 50 percent less time to learn their tasks, and 90 percent of the students questioned preferred simulators to conventional training (instructors gave mixed reviews).[186]

A key question, of course, is whether the quality of the training received is as good as conventional methods. Are the topics learned retained longer? Are they more easily transferred to practical applications? Such questions are virtually impossible to address

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[180] See Billy Reagan and Patricia Sturdivant in "Education," op. cit., footnote 155.

[181] E. Hanushek, "Throwing Money at Schools," *Journal of Policy Analysis Management*, fall 1981, pp. 19-41.

[182] J.S. Coleman et al., *Equality of Educational Opportunity* (Washington, DC: U.S. Government Printing Office, 1966).

[183] D. Armor et al., *Analysis of the School Preferred Reading Program in Selected Los Angeles Schools* (Santa Monica, CA: The Rand Corporation, 1976).

[184] See *Technology and Structural Unemployment*, op. cit., footnote 163; and Richard E. Clark, "Reconsidering Research on Learning from Media," *Review of Educational Research*, winter 1983, vol. 53, No. 4, pp. 445-459.

[185] J. Orlansky, op. cit., footnote 169, p. 9.

[186] Ibid., p. 28.

Table 6-5.—Measured Effects of Defense Department Flight Simulators, Computer-Based Instruction, and Maintenance Simulators

Factor	Flight simulators	Maintenance simulators	Computer-based instruction
Student time savings	50 percent	20-50 percent	30 percent
Acquisition cost savings	30-65 percent	20-60 percent	NA
Operating cost savings	8 percent	50 percent	NA
Life-cycle cost savings	65 percent	40 percent	NA
Amortization	2 years	4 years	NA

NA = not applicable.

SOURCE: J. Orlansky, "The Cost Effectiveness of Military Training," in *Proceedings of the Symposium on the Military Value and Cost-Effectiveness of Training*, NATO headquarters, Defense Research Group on the Defense Applications of Research, (DS/A/DR(85)167), Brussels, Belgium, January 1985.

with existing data. Evaluations conducted in the past decade necessarily combine results of well designed and poorly designed programs (by comparison, imagine an evaluation of automobiles conducted in 1910). The available evidence, however, seems to suggest that computer based instruction is at least as good, if not slightly better, than conventional methods ranked on the basis of quality (most evidence is anecdotal, and is limited by the fact that the state-of-the-art in instructional software and hardware is changing at breathtaking rates):

- A review of 24 evaluations of educational technology found that new technologies could cut learning time by 25 percent, as compared to conventional instruction; 5 of the 24 were in basic education and the rest in specialized technical subjects.[187]
- The Adult Basic Literacy Education (ABLE) in Central Piedmont Community College in Charlotte, NC, found that the average student needed only 21 hours to gain one grade level in reading and math, whereas the average time had been 150 hours.
- A review of 28 studies of newly introduced video-disk training systems used by corporations and the military found that achievement was improved in over 60 percent of the cases reported, user attitudes were improved in 56 percent, and training time was reduced in 80 percent (20 percent of the cases reported mixed results).[188]
- IBM's "Writing to Read" program, described earlier, has consistently shown an ability to increase learning rates of kindergartners and first graders. An advanced system designed to teach literacy skills to adults has consistently shown an ability to increase measured grade levels by 2 to 3 years during a 20-week course.[189]
- A number of specific applications have proven highly effective: Federal Express has reported a 50 percent increase in the learning rates of agents in training; McDonnell Aircraft has reported a 33 percent increase in efficiency in teaching computer-aided design drafting; and the University of West Florida has reported a 24 percent increase in speed in teaching new health workers.[190] The Massachusetts Mutual Life Insurance Company's system claims to have reduced learning time by as much as 50 percent.[191]

There is also clear evidence that students enjoy the experience of working with technology in the course of learning. For example, in a basic education program in Great Neck, NY, 98 percent of the students said that they enjoyed studying with a computer and were particularly impressed by the clear explanations and immediate feedback provided. Three-quarters said that they would like to spend more time on a computer while only 5 percent asked for less.[192]

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[187] Chen-Lin, C. Kulik, James A. Kulick, and Barbara J. Shwalb, "Effectiveness of Computer-Based Adult Education," Center for Research on Learning and Teaching, University of Michigan, presentation to the American Educational Research Association meeting, Chicago, IL, March 1985.

[188] J. Bosco, "An Analysis of Evaluations of Interactive Video," *Educational Technology*, May 1986, pp. 7-17.

[189] "Literacy Program is a Revelation for Non-Reading Adults," *Technological Horizons in Education*, vol. 15, No. 2, September 1987. pp. 81-82.

[190] J.W. Nelson, "Evaluation Data on Successful Applications of Technology Based Training Systems," U.S. Department of Commerce, Washington, DC, October 1987.

[191] V. Nelms, op. cit., footnote 176.

[192] Norman D. Kurland & Associates, "The Role ot Technology in the Education, Training, and Retraining of Adult Workers," contract report prepared for the Office of Technology Assessment, Oct. 5, 1984.

Structural Effects

Most enterprises where information technology has the potential to make significant changes in productivity have found that the potential cannot be achieved without basic changes in management. Education is unlikely to be an exception. A real improvement in the productivity of the Nation's educational system will require asking basic, blunt questions about what is being learned, how it is being learned, when it is being learned, where it is being learned, and why it is being learned. There is growing sentiment that a fundamental review is in order (see box 6-C). At issue is whether institutional mechanisms needed to conduct research and to test results are adequate.

Few educational institutions are organized in a way that allows real attention to productivity improvement. School decisions are often highly fragmented and politicized. School systems typically resist proposals for reform; university instructors are among the most recalcitrant. This has both healthy and unhealthy results. Teachers tend rightly to be skeptical about any new "grand scheme" for reform—particularly so in reacting to claims that technology can provide good pedagogy. They require convincing proof that schemes proposed for using technology can be an advantage for their students.[193] Skepticism is justified since, as might be expected, some of the computer based instruction packages offered initially were poorly designed.

The incentive systems governing educational investment in private industry are fundamentally different from those governing education in traditional school settings. In a corporate setting or the military, where students are paid for their time as well as the teacher, it is obvious that the productivity of a student's time is worth more than teacher productivity by a factor roughly equal to the student-teacher ratio. In most public school settings, however, the perceived cost of a student's time is zero. Organizations that pay the salaries of both teachers and students appear to be far more likely to investigate innovations in teaching techniques than those for whom the cost of a student's time is zero.

In fact, privately funded training has changed the structure of education more rapidly than public institutions. Interviews with 218 large U.S. companies have found that 60 percent of these firms have made significant changes in training methods and training technology over the past decade.[194] They reported extensive use of television, computers, live videotape playback, and satellite television networks. One company used satellites to tie 67 of its locations together so that training in sales and servicing could take place without extensive travel. The Defense De-

Box 6-C.—Some Views on Technology and Structural Change in Education

"The introduction of a substantial amount of information technology into conventional classrooms as they operate today will, in my belief, produce only marginal improvement in educational effectiveness. It will take substantial institutional changes to bring about the improvement that we are seeking; the school environment must be altered to provide motivation, self-paced progress, and integration of out-of-school learning experiences. It will also be necessary for parents to develop new expectations for their children's education."

Lewis Branscomb
Harvard University
(formerly of IBM)

"I am persuaded that the existing K-12 school bureaucracy is having its last hurrah, and that designing new models for education that serve all Americans is of vital importance. A fundamental shift in the nature of the education system is not only possible, but essential."

Theodore Sizer
Chairman, Department of Education
Brown University

"If technology cannot be used to bring about a radical restructuring of how we teach, then its effect will be nil."

"We should not flinch from the fact that we are talking about a revolution in education."

Richard M. Cyert, President
Carnegie Mellon University

SOURCE: U.S. Congress, Office of Technology Assessment, "Education," sector study, Washington, DC, 1987.

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[193] See "Education, op. cit., footnote 155.

[194] Seymour Lusterman, op. cit., footnote 158, p. v.

partment has also invested heavily in advanced instructional technology.[195]

Measured by the zeal with which they are purchasing computers, public school systems appear to be moving rapidly toward greater use of instructional technology. While barely 10 percent of U.S. elementary schools had computers in 1981, more than 90 percent had them in 1986. Nearly all American high schools had computers in 1986. The schools now average one computer for every 37 students.[196]

It is more difficult to determine whether the new information technology is leading to significant changes in the productivity of learning and teaching. Most equipment appears to be used in relatively straightforward ways. Less than one-fifth of all applications are used for purposes other than "drill and practice," teaching computer programming, or word processing.[197]

Scale and Scope.—Will the increased use of capital equipment make schools and training more like an undifferentiated commodity, or more closely adapted to individual needs? Both directions are technically possible. Properly used, the technology could be used to encourage questioning and to explore alternatives. A system that frees teachers to spend more time with individual students could make teaching and learning less and not more mechanical. The high cost of producing software systems for new technologies could, however, lead to the replacement of individual authors and teaching styles with teaching approaches developed by bureaucracies or large teams of people.[198] There is also a risk that inflexible and unimaginative software could crush the spirit of inquiry and reward unquestioning obedience to the "one right way" accepted by a machine.

Judgements about whether technology will increase or decrease flexibility and change the desirable scale of educational operations are made difficult because so little is known about the flexibility of the existing system of education. At first blush, the system appears to be highly decentralized and capable of tailoring instruction to individual needs. But closer examination seems to indicate that decentralization has created stunning uniformity. A survey of 1,000 classrooms across the United States found unexpected uniformity in what was being taught, in how it was being taught, and in the texts from which it was taught.[199] From most points of view, there has been relatively little change over time in the nature or content of instruction in elementary and secondary schools, or in the time spent in school. This uniformity is encouraged by the use of textbooks written to satisfy a broad market.

If the decentralized system is to be effective in providing instruction tailored to individuals, teachers must have some way to keep track of the progress of individual students, and to identify individual sources of confusion and individual receptivity to different pedagogical strategies. Teachers report that it is virtually impossible to accomplish this for 20 to 40 students at a time in a classroom, or for 100 or more students during a day. The pacing of instruction must be keyed to the teacher's sense of the average progress of a class—something that is inevitably a crude compromise even for the most talented instructor. One observer has argued that most teachers stop when from 30 to 50 percent of a class understand about 80 percent of what they need to know to master a subject.[200] As a result, few students completely understand the subject before they are forced to go forward. Similarly, another study has indicated that an average of 20 percent of the students experienced difficulty understanding the teacher's comments or directions at any given time.[201]

No comparable study has been conducted in colleges and universities. College and university education in the United States is also highly decentralized. But few institutions give any systematic thought to the productivity of teaching and learning on their own campuses, and the use of technology is idiosyncratic. Many colleges employ technology not to individualize instruction but to permit students in "mass" lecture courses to see the instructor.

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[195] See J. Orlansky, op. cit., footnote 169. Defense Department budget documents cited in this report, which appeared in January of 1985, show $39 million spent for "education and training," $87 million for "human factors," $38 million for "manpower and training," and $227 million for "simulation and training devices."

[196] U.S. Congress, Office of Technology Assessment, "Trends and Status of Computers in Schools: Use in Chapter 1 Programs and Use with Limited English Proficient Students," staff paper, Washington, DC, Mar. 13, 1987.

[197] 1985 National Survey of Instructional Uses of School Computers, Center for the Social Organization of Schools, Johns Hopkins University, cited in Ibid.

[198] Arthur Wirth, "The Violation of People at Work in Schools," working paper, Department of Education, Washington University, St. Louis, MO, 1987.

[199] John I. Goodlad, op. cit., footnote 178, p. 112.

[200] Benjamin Bloom, cited in John I. Goodlad, op. cit., footnote 178.

[201] John I. Goodlad, op. cit., footnote 178.

Geography.—New technology has the potential to reshape the landscape of education, primarily combining geographic decentralization with an increase in the scale or scope of management. The effect is more likely to be felt by universities offering courses for large numbers of students on one campus, but it could also reduce the size of large high schools or other facilities in urban areas. The key is an ability to deliver specialized courses without having a specialized instructor, library, and experimental apparatus at each location. It is clearly easier for people to continue to receive training and instruction throughout their careers if they do not need to physically move to where instruction is available.

Closed broadcast technology is already being used to deliver instruction to people watching in rooms supplied by their employers. Stanford University has a program where students in a corporate facility watch a videotaped lecture in the presence of another employee of the firm with professional credentials in the subject area, who answers questions during and after the viewing. The TAGER system in Dallas/Fort Worth ties together 17 universities with a closed-circuit network for graduate level engineering business and computer science. Rio Salado Community College in Phoenix, Arizona has no classrooms; the college uses public and commercial television, cable television, audio teleconferencing, slow-scan television, and videotape.[202]

The emerging generation of technology could obviously do more. It might even permit major universities to offer courses and degrees throughout the Nation, through what amounted to small franchise operations tied to the central campus by advanced communication systems.[203] While the prestige associated with ivy covered campuses will undoubtedly always play a major role in helping people make important contacts and obtain attractive jobs, the role of colleges in delivering practical training may well change. It is possible that improved teaching will make it possible to give people what amounts to a good junior-level training by the time they reach 18. It is also possible that employers will be increasingly interested in specialized training, with the understanding that new employees will need to be retrained every few years.

Under these circumstances, is it the role of a university to give the student an initial specialty with the assumption that subsequent specialties will be taught by employers? Should universities screen out individuals likely to fail in different occupations? Is the university's central role one of providing students with basic intellectual tools and a capacity for understanding their culture?

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[202] R.J. Lewis, "Research Questions on the Impact of Computers in the Classroom," The Ontario Institute for Studies in Education, University of Toronto, Toronto, Canada, 1983.

[203] F.D. Fisher, "Higher Education Circa 2005," *Change*, January/February 1987, pp. 40-45.

PERSONAL BUSINESS AND COMMUNICATION[204]

Structure and Performance

The telephone, banking, insurance, legal, accounting, and other businesses that deliver communication and business services to individuals and businesses are at the core of the much discussed "information economy," and are most obviously affected by the capabilities of new information technology. Powerful and inexpensive computers, high-speed communication made possible by relatively low-cost microwave systems, satellite links, fiber optics, high-speed switches, the ability to store massive volumes of data in ways that permit easy access, and a variety of other new kinds of equipment have the potential to fundamentally reshape industries whose primary function was routine paper-pushing. They also have the potential to create entirely new lines of business in areas where services need to be tailored to specific applications. Indeed, a rise in consumer, government, and business demand for these "transactional" products has been responsible for a significant share of U.S. economic growth during the past 15 years.

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[204] Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Communications and Information," sector study, Washington, DC, 1987.

This technical revolution has, in turn, undermined (some would say overwhelmed) the regulatory apparatus that evolved over decades around older systems. Such pressures, combined with new attitudes toward market freedom, have weakened or eliminated many ancient regulatory constraints on telephone services, insurance, and banking. Intense competition for long-distance telephone service has replaced the heavily regulated AT&T monopoly. Insurance regulations implemented over generations for a wide range of purposes (primarily at the State level) are being reviewed and modified.[205] Taken together, changes in technology, demand, and regulation, and the intense competition engendered by these changes are in the process of revolutionizing some of the stodgiest enterprises in America—and some of the Nation's leading employers.

The rules governing the telecommunications and broadcasting industries have been radically reshaped by changes in regulatory policy during the past few years. The "Carterfone" decision, the "Modification of Final Judgment" (disbanding the Bell System), the Federal Communication Commission's deregulatory initiatives established in "Computer II," "Specialized Common Carrier," "Computer III," and other proceedings, have facilitated competition, innovation, and entry.

Clearly the cast of characters has expanded considerably. In addition to the components of the old Bell system, independent telephone companies, and other common carriers, financial service providers such as credit card companies, banks, brokerage firms, and insurance companies have invested heavily in national and international communication systems. Some of these enterprises have expanded their networks to offer investor and financial information for remote users. Citicorp is a leader in this kind of private networking by financial institutions. It uses two Westar V satellite transponders, is a digital termination system vendor, and plans to offer both information and network services nationally.

Railroads, as well as electric and gas utility companies, have long utilized private microwave facilities for command and control of their network operations. They own or control extensive rights-of-way, especially railroads with rights-of-way that connect urban centers and have been active in providing rights-of-way, by sale or joint venture for the construction of intercity coaxial or fiber optic transmission systems. GTE Sprint, the third largest interexchange common carrier, developed from Southern Pacific's private microwave network.

As the information processing and data transmission industries merge, integration by many manufacturers into at least some transmission markets is taking place. Mitel and American Satellite have formed a joint venture, EMX Telecom, to provide end-to-end telecommunications services. Finally many large firms are assessing the feasibility, for their private networks, of providing their own (Integrated Services Digital Network (ISDN) facilities—using T1 carrier circuits obtained from AT&T's competitors, satellite transponders, or excess capacity of other users' internal networks, rather than leasing lines from telephone companies.

While growing use of advanced computers and communication equipment has increased the capital invested by the network of businesses that delivers communication and business services such as legal help, financial services, insurance, and real estate, these businesses remain comparatively isolated from the rest of the economy. Of the value-added generated in serving consumer and government needs for the Personal Business and Communication amenity, 70 percent remains in the sector classified as Transactional Activities (see figure 6-9).

Information transactions are still dominated by human expenses and not equipment costs. The costs of a telephone call or a letter are irrelevant compared with the time spent preparing the material. The cost of using advanced databases is dominated by the personal costs needed from the producer to prepare the information and from the purchaser who retrieves and interprets it.

Prospects

Will all of the institutional shuffles just described result in real competition and flexibility in the Nation's information industry? The answer depends both on decisions made by regulatory authorities in

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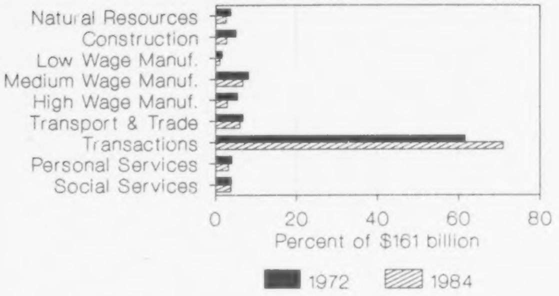
[205] Regulations in insurance cover consumer protection, licensing of companies, restrictions on the types and quality of company investment, regulation of rates and advertising, limits on grounds for cancellation and non-renewal, provisions for minimum coverage, regulations on underwriting criteria, cost disclosures, unfair trade practices, and transactions between parent companies and affiliates.

Figure 6-9.-Value-Added To Meet Demand for Personal Business and Communication ($161 billion* in 1984)



*Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

the near future and on how formerly regulated companies survive the transition to competitive markets. Competition will also be heavily influenced by the way explicit and *de facto* standards are adopted throughout the industry. An open system, such as the architecture of the IBM personal computer and the MS-DOS operating system, clearly led to an explosion of hardware and software developments by firms of all sizes.

Regulation

Message Service and Information Processing.—The creation and maintenance of communication monopolies "regulated in the public interest" could be justified by arguing that the economies of scale possible under monopoly regulation can lead to prices so much lower than those likely to be available in a competitive environment that they offset any consumer advantage that may exist under competition. But while regulation can avoid a situation where a monopoly exploits its privileged position through excessive prices, it can seldom provide adequate incentives for the adoption of new, cost-saving products or services.

The logic of telephone regulation was undermined by technology in two principle ways. First, the clear "natural monopoly" advantages of economies of scale were undermined by the explosion of competing technologies for the provision of long-distance service. Relatively inexpensive microwave and satellite relay systems can now, for example, be operated by a variety of companies at prices competitive with AT&T. For some markets there is a debate about whether the provision of local area service, now restricted to the Bell Operating Companies, has also lost monopoly advantages.

Second, the logic of regulation collapsed because of the growing overlap between the provision of standard telephone service and activities involving the storage and processing of information where regulation was clearly unjustified. It became necessary to make painful distinctions between different types of advanced telephone equipment and a variety of "value-added" services such as computing and data services, protocol conversion (converting the language of one computer to a form where it can be interpreted by another), electronic mail, database services, electronic publishing, voice store and forward (a sophisticated "phone answering machine" that can store voice messages and permits intended recipients an opportunity to call into the system at any time and hear sorted messages), and alarm and telemetry services. It proved difficult to find a way to make adequate use of the Bell System Operating Companies' (components of the old AT&T system) enormous sophistication without allowing them to take unfair advantage of their regulated access to local telephone markets. At present, the Bell operating companies are allowed to provide some kinds of electronic information services (message storing and electronic advertising), but are still prevented from providing most long-distance services and making telephone equipment.[206]

The series of mergers and acquisitions in telecommunications has resulted in part from the decision to dismember the Bell system along market lines, instead of simply separating communication markets into a series of vertically integrated regional firms. It is possible that the latter choice would have resulted in more effective competition in end-to-end services and perhaps better international competition. The point may ultimately be moot, however, as an increasingly unregulated market moves rapidly to create end-to-end competition despite the original regulatory intent, and as restrictions on the Bell Operating Companies are removed.

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[206] C. Sims, "Most Regulatory Curbs on 7 'Baby Bells' Kept," *The New York Times*, Sept. 11, 1987, p. D1.

By the end of this decade, the current telecommunications marketplace is likely to consist of select "tiers." A central sector will consist of fully integrated end-to-end suppliers who primarily employ their own facilities to offer users a complete "package" of services. Among the firms most likely to be major players in this sector are AT&T, the seven Bell Regional Holding Companies, and perhaps some of their larger competitors (MCI, GTE, United, and Continental). A second tier would consist of equipment and carriers' "carriers." For instance, the fiber optic networks will provide strong competition to AT&T in the carriers' carrier sector, while Northern Telecom and IBM/Rolm will be similarly successful in the network equipment and large private branch exchange (PBX) area. Industry "shakeouts" are currently underway in long-distance markets as well as in large switching equipment (especially digital), PBXs, and key sets.

Even within such an oligopolistic market structure, there will be many opportunities for firms to apply organizational advantages of large scale production and vertical integration. However, in each of the supply tiers, there may be problems of discrimination, cross-subsidy, and access to technical information. In sub-markets, particularly those of limited population and traffic density, supply will retain many monopolistic attributes. In central core areas, supply bottlenecks in local exchanges for basic service will remain and provide the most attractive area for application of structural separation. In other words, while the new regulatory environment for communications has opened opportunities for competition in areas traditionally controlled as "natural monopolies," it is likely that the industry will continue to be dominated by enormous firms that yield only a small fraction of their total business to companies serving relatively small niche markets.

In spite of rapid automation of many activities, the costs of human time and talent should continue to dominate the production recipe in communication and data processing. Given that a way is found to restructure management to take advantage of new information technology and overcome cultural barriers to new communication modes, this blunt fact will remain a significant economic constraint on the way new communication technologies are used. For example, the cost of message delivery primarily involves the time invested by the individuals sending and receiving the information.[207] Labor costs associated with management and the time spent reviewing data, for example, represent nearly 90 percent of the cost of database services, with capital costs of communication and computer equipment and the cost of communication services representing the rest (see table 6-6).

The cost of preparing a first-class letter in an ordinary business may be on the order of $20 to $30, while the cost of postage is only 25 cents. The cost of an average 10-minute long-distance business telephone call is $16.24, of which $8.97 is for communication services and the rest is the result of employee time.

Figure 6-10 illustrates the relationship between price and demand for different kinds of point-to-point communication services. Demand for mail has proven to be extremely inelastic, since mail delivered per person has continued to increase sharply even though real prices have increased.[208] The elasticity of demand for telephone service is negative. Long distance telephone demand appears to increase by 10 percent when prices fall by 10 percent (a price elasticity of -1.0), while local telephone usage seems to increase by only 2 percent when prices fall by 10 percent (a price elasticity of -0.2).[209]

Broadcasting and Print Media.—Regulation of broadcasting and print media are discussed in the next section, which describes the network of busi-

Table 6-6.—Production Costs for a Database

Cost area	Percent of costs
Sales, marketing, and administration	45
Content acquisition	40-45
Data communications equipment, front-end processors, database storage	6
Communication services (local exchange, long-distance value added net or public switched)	7-8

SOURCE: Peter W. Huber, *The Geodesic Network: 1987 Report on Competition in the Telephone Industry*, prepared for the U.S. Department of Justice, Antitrust Division (Washington, DC: U.S. Government Printing Office, January 1987), based on Link Resources Corp., "Pricing and Marketing On-line Information Services," 1986, pp. 17-18; Dun & Bradstreet; and other sources.

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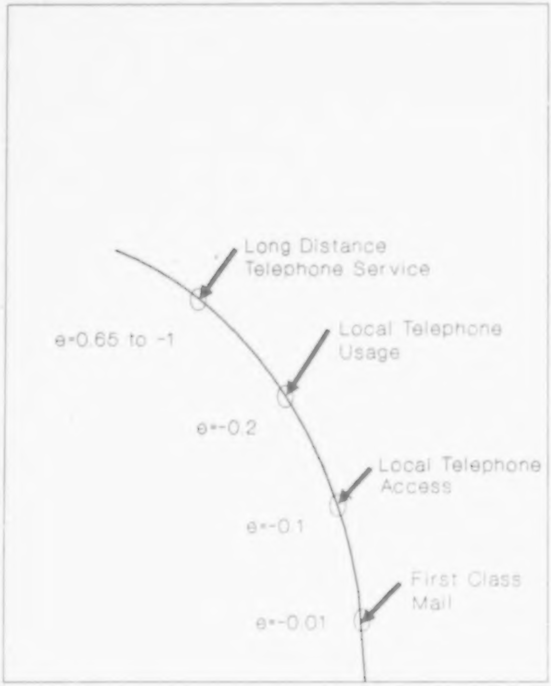
[207] I. de Sola Pool et al., "Communications Flows—A Census in the United States and Japan," North Holland, Amsterdam, 1984.

[208] "Communications and Information," op. cit., footnote 204.

[209] Lester D. Taylor, *Telecommunications Demand: A Survey and a Critique* (Cambridge, MA: Ballinger Publishing), 1980.

Figure 6-10.-Hypothetical Relationship Between Price and Quality of Message Services (e=price elasticity)



SOURCE: U.S. Congress, Office of Technology Assessment "Communications and Information," sector study, Washington, DC, 1987.

ness that provide the Recreation and Leisure amenity for Americans.

Information Processing.—Telecommunications and computers have traditionally been considered separate industries, partly because of legal constraints. AT&T,was not permitted to sell or produce computers for anything other than use within the Bell system.[210] As telecommunications networks are, in an important sense, computers (or at least a primary example of the application of computers), this ban did not stop AT&T from emerging as a major presence in the industry.

The regulation of telecommunications also prevented computer companies from competing in the telecommunications arena. Nevertheless, the growth of distributed processing and computer terminals in the 1970s made computer communication dependent on facilities supplied by the regulated public telephone network. Frustration with certain parts of this system led to the development of alternative special networks for data even as the proliferation of computers in the office and factory led to the creation, by computer companies and others, of "Local Area Networks." Computer and telecommunications firms began to overlap and compete. There is growing demand for systems that combine voice and data communication.

The rules have changed. AT&T and IBM will compete in each other's traditional markets because regulators removed restrictions on AT&T's computer activities after the court-ordered Modification of Final Judgment,[211] and because several decades of regulatory changes have allowed more competition in the provision of communications equipment and services.

Intermediate Demand

Table 6-7 provides a crude review of the relationship between intermediate and final demand for information services in 1977. While the data are old (1977 was the last year for which detailed statistics are available on intermediate demand in the categories shown), the table provides some indication of the relationship between intermediate and final demand for information.

Some communication services have actually decreased as a fraction of all "intermediate demand" in the U.S. economy during the past few decades, in part because prices have fallen in many areas. Paper and publishing was 5.1 percent of all intermediate inputs in 1963 and 4.1 percent in 1977. Communication services decreased from 1.8 percent to 1.6 percent of intermediate demand during the same period.

Network Components

Insurance.[212]—Three features of the emerging U.S. insurance system deserve attention:

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[210] This decree was issued in an antitrust case brought by the Justice Department to constrain this communications giant from dominating the nascent computer industry.

[211] This occurred as of Jan. 1, 1984, and technically, modified the 1956 Consent Decree.

[212] Much of this discussion is drawn from Barbara Baran, "Technological Innovation and Regulation: The Transformation of Regulation in the Insurance Industry," contract report prepared for the Office of Technology Assessment, Washington, DC, January 1985.

Table 6-7.—Demand for Information and Data Processing by Major User Group

	Percentages			
	Intermediate demand	Personal consumption	Government demand	Total use (1977 $millions)
Communication services:				
Communications (except radio and TV broadcasting)	44	42	5	52,868
U.S. Post Office	72	21	7	12,935
Data processing services:				
Computer and data processing services	83	0	16	15,394
Information goods:				
Printing and publishing	52	32	12	31,849

NOTE: Percentages may not add to 100%, since total use also includes inventory changes and consumption of producer durable. These are quite small for the categories indicated here.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "1977 Input/Output Tables," *Survey of Current Business*, vol. 64, No. 5, May 1984.

1. a radical change in the way work is organized within the enterprises, which eliminates most routine clerical tasks and routine professional tasks (such as standard underwriting decisions);
2. fierce competition in areas traditionally enjoying protection for generations; and
3. a radical change in the geography of production, as some functions (such as central records keeping) become highly centralized and others (such as routine underwriting) are decentralized.

The increased range of services made possible by new technology are forcing consumers to ask penetrating questions about exactly what they are purchasing, and what features of the services they value. And the technology, combined with the new pressures of competition, is forcing producers to ask unprecedented questions about precisely how these services are provided. This has resulted in subtle but fundamental changes in how these enterprises go about delivering their services and frequently in basic changes in management practices and job descriptions throughout the enterprise.

Work Organization.—Insurance firms were among the first companies to make heavy use of computers, and at one time owned 16 percent of IBM's installed capacity. The computers were, however, used almost entirely to automate "back office" work like record entry and bookkeeping, and had virtually no influence on the way most work was managed. The industry is now undergoing a second and much more radical kind of automation, in which basic management strategies are coming under intense scrutiny and virtually every operation will be redefined. The primary motivations are product diversification, error reduction, improvements in service quality and speed, and the quest to be competitive; both the primary and second phases of this process are described in box 6-D.

There has been enormous institutional resistance to the implementation of such programs. The link to sales has proved to be particularly difficult to automate. Traditionally, most insurance was marketed through one of four mechanisms: independent agents and brokers, exclusive or "captive" agents, salaried employees or direct writers, or direct mail. Captive agencies and direct writers have moved to adopt new technology, while independents are moving comparatively slowly. Competitive pressure may force independents to move at a faster rate.

Competition.—Changing regulations, growing consumer sophistication, and new technology have combined to introduce ferocious competition in areas where the word was once considered impolite. Competition has grown around price, product innovation, and service quality. The "bundled" services of whole life, for example, are rapidly being separated into components: investment, risk-protection, and services. Unprecedented competition has emerged both in the provision of low-cost insurance "commodities," and in sophisticated financial and investment services. Banks and investment houses now offer money market funds and other services that often provide more attractive investment opportunities than life insurance. Between 1976 and 1980 premiums fell more than at any time since the turn of the century, and processing times have been greatly reduced.

Similar patterns prevail in commercial insurance. Corporate risk managers have increasingly compared the merits of commercial insurance with the merits of self-insurance or captive insurance companies that may provide equivalent risk coverage more efficiently. The "bundled" functions of property/casualty insur-

Box 6-D.—The First Phases of Automation

The first stage: Issuing a check

If a check had to be issued, first it was typed by a typist; then another clerical verified the amount; a third person audited the claim to insure that the doctor charged appropriately for the service provided; a fourth person actually "burst" the check [took apart the carbons]; and a fifth then put the check through the signing machine. Including supervisory oversight, between six and seven people were involved in this one procedure alone. Claims needed to be typed and retyped. Reports of several kinds needed to be prepared for accounting and management functions. Multiple copies of records prepared to update several files.

Back office "electronic sweatshops"

Data entry was typically separated in organizational terms, and often geographically, from middle management. Typically working in huge, open offices, workers were grouped by function: underwriters, raters, typists, file clerks. Clerical work was machine paced, and in some cases lines of text typed per hour were monitored by machine. Turnover rates for employees was very high. In 1979, a text processing center for Travelers Insurance operated around the clock and turned out an average of 6,000 letters each week. It employed 35 typists, 11 of whom transcribed full-time and 27 part-time on a 6 PM to 10 PM shift each night or at peak hours to maintain a goal of 24 hour turnaround.

The second stage: Group Health underwriting

1. Commodity-like products (standard life insurance policies, group health, automobile and homeowner insurance, etc.) are offered through streamlined channels in which a highly skilled clerical employee or salesperson,[1] enters data directly into terminals linked to central data-processing facilities via the IIR/ACCORD network, IBM's IVANS [Insurance Value Added Network], or some other network. Skilled clericals, rather than professional claims examiners, are thus able to handle routine claims and order necessary inspection reports. Once entered, data that formerly needed to be typed and retyped need only be entered once. Information for claims, accounting and management reports, and other functions can be obtained from centralized data files that are automatically updated. The new systems are able to identify exceptional cases, presenting them to underwriters and claims examiners trained to handle cases that fit no standard role. The process is called "underwriting by exception," "pigeon-hole underwriting," or "computer assisted underwriting." A survey taken in the early 1980s found that firms making relatively straightforward investments in the automation of agent functions averaged a 70 percent increase in output in the first two years compared, with only a 17 percent increase in firms not investing in automation.[2] Regional offices can thereby be reshaped into multi-activity teams that combine typists, raters, and underwriters. Some 71 percent of property/casualty firms and 44 percent of life companies surveyed indicated that they instituted this form of organization.

2. Most forms of commercial insurance, and services for high-income individuals interested in sophisticated financial packages, cannot be automated in this way. Commercial insurance has necessarily continued to emphasize flexibility; highly sophisticated, tailored products; specialized services such as loss control engineering; and rapid claims handling. Competition in services of this kind requires agents close to the market. Computers are used to assist highly skilled professionals to tailor products for customers rapidly and to work through a variety of options.

SOURCE: *The Office*, 1979, cited in Barbara Baran, "Technological Innovation and Regulation: The Transformation of Regulation in the Insurance Industry," contract report prepared for the Office of Technology Assessment, Washington, DC, January 1985.

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[1] Jobs created in systems like the one described here are so new that they have complex and obviously synthetic titles, like "para-technical," "professional-clerical," "para-professional," or "skilled clerical."

[2] *National Underwriter*, May 13, 1983, pp. 18-22.

ance (e.g., fire, workmen's compensation, auto liability, and auto physical damage) became unbundled and sold separately.

While regulations still place severe limits on interstate bank offerings and bank entry into insurance, the rules are constantly under assault. Many States now allow life insurers, for example, the option to forgo inefficient subsidiary systems as well as the freedom to widen their investment portfolios. Many insurance companies have been acquired outright by industrial or financial institutions such as ITT and American Express.

Scale and Scope.—Most of these changes work to the advantage of large firms. This encourages both horizontal and vertical integration of functions in firms that can take maximum advantage of the dynamic performance of new automation.

About 4,900 licensed insurance companies were operating in the United States in 1983, of which 60 percent were in property/casualty and 40 percent in life insurance. But a wave of mergers and acquisitions that started in the 1960s has begun to consolidate this diverse industry with astonishing speed. A recent study estimated that within the next two decades virtually all insurance would end up in the hands of 10 to 15 percent of companies now operating.[213] Large, multinational firms and increased government health coverage are expected to dominate most of the industry, leaving a modest number of market niches to specialty companies.[214] Concentration is likely to be particularly dramatic in the area of sales, where parent firms will attempt to invoke tighter control over distribution systems. Some concentration will also take place by integrating insurance and financial services. Citicorp, for example, has set up an insurance operation, and Prudential holdings now include a brokerage house and a bank.

Geography.—All of these developments have had contradictory effects on the geography of work. Some functions, like data storage and large-volume "number crunching," enjoy economies of scale or require integration of data files and are growing increasingly centralized. Others, typically those that benefit from rapid and flexible response to consumers, are becoming more decentralized.

In the 1960s, most large insurance organizations maintained numerous regional and branch offices as well as a network of field or sales offices. During the late 1960s and 1970s, many regional network offices were extended to "get operations closer to agents and customers." The second wave of automation technology, however, allowed data entry and other work to be accomplished efficiently in the field. This made it possible to return the functions of regional offices to home offices.

Large operations, primarily clerical, can now be located virtually anywhere. Under the first phase of automation (again see box 6-D) only highly standardized "back office" functions could be located in suburbs remote from corporate headquarters. But with new communication networks, entire integrated production and service facilities can be "burbed" to make them more accessible to a desirable labor pool: suburban housewives.

This centralizing force is offset by technology allowing much data entry, printing, and processing to be accomplished at the point of data generation—often in field offices. The portion of centralized data processing requiring large numbers of entry clerks and operators accomplishing routine tasks is often eliminated by work done on field terminals.

Banking.—Banking has undergone a similar transformation. Regulations that prevent interstate banking, and in States like Colorado even prevent branch banking, still impose major barriers to system integration and greatly restrict geographic centralization of operations. There is, however, enough flexibility in the system to permit a good deal of change. Pressures are being brought to bear to encourage further loosening of Federal and State controls on banking, while at the same time aggressive banks like Citicorp are finding increasingly sophisticated methods of exploiting loopholes in existing statutes. As a result, consumers face more choice, freedom, and risk than they have in the past.

Banks are making extensive use of electronic fund transfer systems that substitute for paperwork. The largest is the Fedwire system, operated by the 12

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[213] Life Office Management Association, "Branch Office Clerical Salary Survey," and "Management Salary Survey," 1982, cited in B. Baran, op. cit., footnote 212.

[214] "Entering the 21st Century: An Insurance Forecast," focus on property/casualty, Florida Association of Insurance Agents, p. 161, cited in B. Baran, op. cit., footnote 212.

Federal reserve banks, which serves 7,000 institutions. Over $600 billion is transferred over the Fedwire and other systems on an average day. Electronic fund transfers have certain economies of scale and have been used primarily by larger banks, but the availability of low-cost microcomputers now allows many small banks to participate.

Automation can also make the sales portion of banking much more efficient. As in the case of insurance, sales appear to be splitting into two parts: the processing of relatively routine transactions (such as checking accounts, credit cards), and highly specialized financial services for affluent individuals and institutions. Automation can both facilitate the handling of the routine "commodity-like" functions and expand the capability and flexibility of the specialized services.

Automatic teller machines have begun to displace many routine teller functions. There were 13,000 automatic tellers operating in 1973 and 59,000 in 1985. By 1990, the industry expects to have 100,000 systems in place—some operating as national networks.

Consumer interest in new banking technologies has been limited. Home banking through personal computers enjoys only a small fraction of individual banking transactions, and sales have not moved much beyond the experimental stage. Barriers to further growth include the cost of home terminal equipment, software that is not completely transparent to non-experts, and relatively inflexible services.[215] A related innovation involves "point-of-sale" systems that permit retailers to debit a person's account automatically at the time of sale; a statewide, multi-bank system with 3,500 terminals is now being tested in Florida. Point-of-sales systems benefit the retailer by eliminating bad checks and invalid credit cards, and by speeding transfer of funds to the retailer's account. The advantages to the retailer are so great that it will probably be necessary to give customers a price break to encourage the use of point-of-sale systems.

It is not difficult to imagine a system that could allow an individual to pay bills, provide detailed analyses of an account's status at any time, sort transactions in ways that facilitate analysis of expenses like utility bills, or document payments for tax purposes. None of these functions would require communication speeds above those available through standard, unconditioned telephone lines.

Advertising.—The advertising industry occupies a unique role in the U.S. economy. Advertising is purchased almost entirely by businesses, and therefore must be considered an "intermediate" product, even though its primary function is to deliver information to consumers. Measured in direct terms, the industry contributes about 2 percent of value-added in the U.S. economy. Its influence over the structure of the U.S. economy is undoubtedly much greater than this modest figure would imply. Much of the information reaching consumers about products arrives through advertising. The firms purchasing advertising obviously feel that their money helps shape public response to their products.

The performance of the advertising industry is crucial to the operation of a dynamic economy. Interviews with producers suggest that an inability to advertise in a limited market is a greater barrier than an inability to produce a large number of specialized items at a competitive price. In the absence of specialist advertisers, therefore, there would be a bias towards mass rather than batch production.

Several recent changes, however, appear responsive to the new interest in identifying and reaching relatively small niche markets. The first involves the structure of the advertising industry itself. While recent movement appears to be away from the specialized creative "boutiques" and toward greater integration, the integrated firms operate on a very different philosophy than that of the "full service" agencies of the 1950s. The present firms seem to be largely orchestrating the activities of a number of subsidiaries that specialize in a narrowly defined areas. Some of these subsidiaries were profitable enterprises simply purchased by larger firms with a relatively well-defined shopping list. In other cases, larger firms explicitly set out to establish creative subsidiaries to meet client needs.

Activities in larger firms include regional and product specialization, and specialization in such strategies as direct marketing, public relations, sales promotion, package design, and corporate presentations. This range of activities allows them to combine the advantages of quasi-autonomous subsidiaries with the economies of "scope" deriving from unified management. In principle, the "flexible oligopoly" that seems to be emerging permits the industry to bring a large variety of clients into contact with a large variety of audiences.

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[215] Lucille S. Mayne, "Technological Change and Competition in American Banking," *Technovation*, vol. 4, 1986, pp. 67-83.

Secondly, changes in technology may make it easier to target relatively small audiences. Cable television, specialized magazines, and other new channels have fragmented advertising markets. Direct marketing has benefited from widespread use of credit cards and efficient local trucking.

Advanced printing machines can tailor magazine advertising to regional and perhaps eventually to individual interests. Envelope-stuffing devices are driven by computers, and mailings are carefully tailored and targetted to known individual profiles. The next logical step is finding a way to permit a customer more direct access to product information from a home information system. Systems like Compuserve, the home and corporate computer network, have a limited, if not devoted, clientele that consists largely of relatively affluent computer buffs, but it is not clear how such a system could be used for effective advertising. A customer going to a terminal with a particular purchasing decision in mind is different from one browsing through a magazine or watching a television show where product information is not the objective of reading or watching.

Geography.—While national agencies are still centered in New York and Los Angeles, there has been dramatic growth in firms located in such rapidly growing urban centers as Orlando, Dallas, and Houston. Some are independent, but many are subsidiaries of major firms that offer a full line of support. They provide intimate relationships with local producers and local markets.

When McCann-Erickson followed Standard Oil of New Jersey overseas in the 1920s, it was the exception and not the rule. But today, like so many other activities in the economy, the advertising industry has become an international enterprise. Advertising firms are playing a critical role in helping U.S. firms find markets abroad; an ability to maintain an effective foreign marketing operation has become almost essential for holding domestic accounts. Equally, U.S. firms have played a major role in helping foreign producers find a home in the U.S. markets. The sale of skilled services in marketing greatly facilitates international trade, with all the benefits and liabilities that this entails.

Understanding international market and having adequate access to foreign media has often involved combining forces with foreign firms. Of the 22 largest advertising agencies in the United States, 17 are multinationals. More than half of the income of several of the Nation's largest agencies currently comes from foreign revenues.

Information Processing and Communication

The patterns of institutional and geographic integration and disintegration described for virtually every sector of the economy depend critically on low cost information transmission and processing. It has, of course, always been difficult to identify the way information is "used" as an input by businesses, since information costs are typically buried in other accounts. But as businesses take more care to examine their consumption of information, it turns out that the cost of information is large, and consists mainly of hiring people and purchasing software rather than hardware costs.

Information-related investments continue to grow rapidly, if more slowly than computer manufacturers once anticipated. By 1986, information technology investments represented more than 30 percent of all business investment. Investments in information equipment did not slow significantly during the severe recessions of 1980 and 1982/83, when other capital spending was sharply reduced. While investments in hardware, such as computers and advanced telephone systems, are relatively easy to identify as "information" investments, most firms soon discover that the real costs of information processing are much larger than direct hardware costs.

Box 6-E provides a rough taxonomy of the functions provided by communications and information industries. The clean divisions illustrated in the table are not easy to identify in actual practice. Much data gathering, for example, now occurs automatically through the use of computers disguised as cash registers, automatic tellers, and terminals in travel agencies. Many "information" businesses provide more than one of these functions (some bundle them all as a service), but increasingly the traditional information industries are finding themselves suppliers

Box 6-E.—Components of the U.S. Communication Industry: Common Carriage and Substitute Services

Exchange service providers
- Bell operating companies
- Independent telephone companies
- Other common carriers
  - —Cellular
  - —Digital termination service
  - —Others

Interexchange carriers
- AT&T communications
- Satellite carriers
- International record carriers
- Bell operating companies
- Independent telephone companies

Carriers' carriers

Resellers, value-added networks, and information service providers

Media entities in common carridge (cable and broadcast companies)

Private and user-oriented systems
- Private systems
  - —Local and wide area networks
  - —Private microwave systems
  - —PBX systems
  - —Electronic funds transfer systems, etc.
- Shared Tenant Services
  - —Smart buildings
  - —Teleports

SOURCE: U.S. Congress, Office of Technology Assessment "Communications and Information," sector study, Washington, DC, 1987.

or components in elaborate networks owned and operated by businesses that do not consider themselves in the information business—witness the extensive communication networks in firms ranging from McDonalds to Citicorp to Federal Express.

Until recently, the industry was governed by several paradigms:

- A clean distinction existed between message service communications (mail, telephone, and telegraph), broadcast communications (radio, television, and publishing), and data processing.
- New technologies in communication would *add to* rather than *substitute for* existing channels.
- Point-to-point communication would need to be regulated because of the "natural monopoly" of the enterprises.
- Regulation would ensure that the telephone service was inexpensive and almost completely undifferentiated—the richest and the poorest Americans would have the same handset and talk over the same phone lines.
- With the exception of publishing, broadcast enterprises would need to be heavily regulated because of the scarcity of available broadcast frequencies.
- With the exception of books, broadcast information would be heavily (or entirely) sponsored by advertising rather than purchased by the ultimate consumer.
- Data processing would be a specialized service delivered primarily to industries with sophisticated information processing requirements.

Today, virtually all of these paradigms are collapsing under the combined pressures of a radically changed regulatory environment and new technology, which have created competition in price and quality of service and rapid differentiation of communication services. "Plain Old Telephone Service" (known in the industry as POTS) is rapidly becoming archaic, as both individual and business consumers are confronted with a variety of long-distance services (i.e., services offering different qualitative characteristics for the rate at which data can be transmitted, privately-owned switching systems within firms, and packet switching that can combine many relatively low-data rate services). Technology has introduced an enormous range of message delivery services competing with the market once limited by POTS, mail, and Telex/telegraph. Express mail, paging services, electronic mail, high-speed facsimile systems, and voice store and forward systems have opened a range of new market niches at a variety of prices (see table 6-8). The distinction between message and broadcast systems has become less distinct, since electronic message and voice forwarding systems can deliver messages from an individual to several different recipients simultaneously.

Acceptance of new technologies has been somewhat slower than expected, in part because the new communication techniques take time to insinuate themselves into the conventions of business in traditional organizations. The lack of an agreed communication standard has also presented problems.

Cellular radio and paging services are competing in markets once limited to mobile telephone, offshore radio, rural radio service, specialized mobile radio, air-ground radio telephone, and maritime mobile services. There were nearly 6 million pagers in use in 1986 and nationwide paging service is now available.[216]

Electronic mail is heavily used in manufacturing enterprises and large firms of all kinds. While only 17 percent of companies with sales less than $1 million used electronic mail, nearly 60 percent of firms with more than $1 billion in sales use electronic mail. The technology has the potential to replace much routine document and message transmission. As presently used, 55 percent of the information sent on electronic mail systems substitute for telephone calls, 10 percent for telex, and only 5 percent for first class mail, courier services, and other electronic transmission; 20 percent of the messages sent electronically appear to be new traffic generated by the technology.[217] Taken together, telex, facsimile, and electronic mail generated approximately $1.5 billion in revenues in 1984.[218]

It is difficult to estimate the extent to which electronic communication will substitute for print. At present, print is cheap, easy to transport, and offers the reader unmatched flexibility. But there is a high probability that some entirely new communication strategy may emerge. There is a growing market for electronic database services (e.g., Dow Jones and LEXIS) that substitute for conventional business information libraries or paper archives. The insurance, banking, and advertising networks described earlier maintain their own proprietary data banks. Manufacturing firms as well as architecture and engineering services are making increased use of drawings and specification files stored in electronic form.

Data communications still accounts for less than 10 percent of telephone company revenues, though data transmission is obviously a growing business. Approximately 13 million pages of information a day are sent through "packet switching" services that allow users to reduce telephone costs. The Federal government generates about 40 percent of this business.[219]

High-speed "dial up" packet switching from companies like Telenet, Tymnet, and Uninet has been available for some time and is used primarily for computer communications. The ISDN is an emerging concept for providing a standard for data and signaling over switched telephone circuits, which would evolve from existing international standards for digital voice communications. The International Organization for Standardization (ISO) is coordinating the work of 89 member nations on ISDN, while in the U.S. standards are being developed by the Consultative Committee on International Telephone and Telegraph (CCITT). As in the case of all standards, a premature choice can miss technical opportunities—but the lack of standardization can create such confusion that markets may materialize much more slowly than they should. Making no collective decision about standards does not mean that a standard will not be set. In the absence of a standard, a large public telephone company in Japan or Europe or a major corporation like IBM may set de-facto standards. AT&T, MCI, GTE, and each of the Bell Regional Holding Companies are presently conducting field trials of ISDN systems.[220] Japan and several European nations also have field trials underway.

Most high-speed channels require a "dedicated line" between senders and receivers, but advances in switching technology are now permitting what is called a "virtual private line" that allows a central office options for routing signals and can make more effective use of central office equipment. Advanced ISDN systems will permit users to select the kind of service required. They could, for example, purchase a high data rate line when massive data transmission rates are needed, and purchase lower speeds when these are needed.

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[216] Peter W. Huber, *The Geodesic Network: 1987 Report on Competition in the Telephone Industry*, prepared for the U.S. Department of Justice, Antitrust Division (Washington, DC: U.S. Government Printing Office, January 1987), Table MB.2.

[217] *EMMS: Electronic Mail and Micro Systems*, vol. 10, No. 5, Mar. 3, 1986, p. 3, cited in P. Huber, op. cit., footnote 216.

[218] Robert Moran, *The Electronic Mail Revolution: Implications for Users and Suppliers*, Business Communications Co., Inc., No. 63, May 1985.

[219] P. Huber, op. cit., footnote 216.

[220] John J. Keller, "Central Office Equipment Makers Preparing for Big Push," *Communications Week*, Mar. 17, 1986; and National Telecommunications and Information Administration, U.S. Department of Commerce, "Issues in Domestic Telecommunications: Directions for National Policy," NTIA Special Publication 85-16, Washington, DC, July 1985.

Techniques for purchasing data processing are becoming more complex as data processing costs of all kinds are dominated by the software and personnel operating the system (see table 6-8). In 1986, there were estimated to be about 3,000 databases, 1,400 producers, and 450 on-line services.[221] Demands for data are dominated by financial and credit services (see table 6-9).

Intermediate Demand for Information Processing.—Businesses use information services for a variety of functions, each of which lead to qualitatively different demands for products and services.

- Extremely large "number crunching" systems are required for an array of functions, including development of high-quality animations for film production, analysis of aerodynamic designs, weather forecasting, and the design of nuclear weapons. While most of these applications formerly were conducted in a "batch" mode submitted by the client to a computer center, applications are increasingly demanding "on-line" systems where an engineer or animator can view the results of a simulation immediately—often through a high-quality graphic representation.
- Process control systems, involving the operation of either a large chemical plant or an array of numerical machine tools, require fast communications and extremely high reliability.
- On-line processing for applications like banking, insurance, or airline reservations require communications, a connection with large blocks of data, high reliability, and functions like the blocking of files while updating occurs.
- Distributed processing is required for office functions like routine payroll and management information systems, word processing, and modest analytical efforts.

There is no effective way to guage the relative rates of growth of these functions.

Table 6-8.—Cost to User of Message Services (cents per message, assuming 1,000 messages per month)

Cost area	Cents per message
In-house PC-based electronic mail	5-7
Service bureau	50-80
Voice storage and retrieval	9-20
Telex 350-760, teletex facsimile	24-143
Overnight courier	850-1,250

SOURCE: Peter W. Huber, *The Geodesic Network: 1987 Report on Competition in the Telephone Industry*, prepared for the U.S. Department of Justice, Antitrust Division (Washington, DC: U.S. Government Printing Office, January 1987), Table EM.5.

Table 6-9.—North American Electronic Information Industry Revenues in 1982 (millions of dollars)

Industry	Revenues
Financial	30.0
Credit	27.7
Legal	9.0
Economics & Econometrics	8.6
Scientific & Technical	6.5
News	3.4
Real Estate	2.7
Other	12.1

SOURCE: Link Resources Corp., "Electronic Information Industry Forecast," No. 4, 1983, cited in Peter W. Huber, *The Geodesic Network: 1987 Report on Competition in the Telephone Industry*, prepared for the U.S. Department of Justice, Antitrust Division (Washington, DC: U.S. Government Printing Office, January 1987), Table EM.5.

New Technologies and System Integration

Given the complexity of the changes just described, it becomes difficult to predict changes in the recipe for delivering communication and business services and information processing. One feature of the production recipe is abundantly clear. While technology will vastly increase the productivity of many information processing functions, the personal costs (and the returns to capital in financial and real estate firms) are always likely to dominate this enterprise. The rising need for specialized services like communications system installation and maintenance, software preparation and maintenance, and other such work will increase inputs from a variety of information-related businesses. The cost of computers and communication equipment, however, is unlikely to dominate overall costs.

Some changes in the approach to the production of communication and information services can be readily identified:

- The telephone industry is examining the role of many "middle management" functions in much the same way as the insurance and banking industries. Services requiring human intervention (information, credit card calls, etc.) are being automated rapidly, and production methods for headsets and other equipment are being scrutinized.

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[221] Link Resources Corp., "Electronic Information Industry Forecast," 1983, cited in P. Huber, op. cit., footnote 216, p. 7.1.

- The distinction between electronic and standard publishing is narrowing rapidly as much text preparation, editorial work, layout, and document transmission is being undertaken electronically. Electronically stored data are transferred directly to printing machines, whose physical location can be chosen to reduce labor costs and delivery times.
- Computers have escaped from sanctuaries presided over by specialists and their power has been distributed widely throughout the businesses they serve, becoming integrated in the routine of ordinary office life. The spectacular decline in cost and increase in power of modern computer equipment is widely recognized.

Interestingly, the process by which computer instructions are created—the production of "software"—though a costly part of the process,[222] continues to bear greater resemblance to medieval craft work than to any 20th century form of employment. Attempts to devise methods for automating the production of software through the use of more transparent programming have proven extraordinarily difficult.

RECREATION AND LEISURE[223]

Prospects

America's recreation and leisure sector is one of enormous diversity. Its six major segments are defined in Box 6-F. The industry is being reshaped by new home entertainment technologies and changes in the regulations governing communications. The overall mix of home and away-from-home entertainment, though, has not changed significantly. If anything, electronic media are serving to stimulate interest in away-from-home activities rather than to substitute for them. Trade has had a major impact; foreign suppliers have all but eliminated the U.S. production of home electronic equipment and has made major inroads into sports equipment, recreational vehicles, and recreational clothing.

Looking to the future, several kinds of change in the structure of this system are possible:

- Technology can lead to a network of businesses that reduce barriers separating creative minds from interested audiences. This could happen because of both reductions in the cost of preparing high-quality paper, audio and video productions, and multimedia products and expansion in the number of channels through which such products can be delivered. The quality of illusion could be greatly increased. Information technology could give viewers more power to choose products tailored to their specific interest. New systems can provide alternatives to passive communication by offering fascinating opportunities for simulations and games. Improved communication channels can reduce some of the uncertainties of travel, and can increase interest in travel to more destinations in both urban areas and rural parks. Greater investment in education on geography, history, health, and the arts could work in the same direction.
- Foreign producers could increase their hold on the products used for recreation at home and away from home. Centralized control over the most powerful communication media, the convergence of publication and electronic communication, and the substitution of pay-per-view for regulated common carrier broadcasting could reduce diversity. High production costs could reduce real competition. Eroding investment in public recreation and park facilities and an inefficient transportation system could reduce choice in recreation for low-income families.

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[222] Software costs represent 80 percent or more of the cost of computerized equipment in major enterprises like the insurance industry. The Defense Department spends nearly 80 percent of its data processing budget on software related services: see John W. Verity, "Empowering Programmers," *Datamation*, Aug. 8, 1986. Similarly, 42 percent of a group of experts in insurance indicated that software costs were the largest single barrier to the diffusion of information equipment in insurance while only 5.5 percent cited hardware costs; See B. Baran, op. cit., footnote 212, p. 57.

[223] Much of this discussion is drawn from U.S. Congress, Office of Technology Assessment, "Recreation and Lesiure," sector study, Washington, DC, 1987.

Box 6-F.—The Major Segments of the Recreation and Leisure Industries

Media refers to recreation and leisure activities utilizing print, video, and electronic media. The products and services of the media segment can be divided into "hardware" such as television sets, books, home electronics equipment, and the like, and "software" such as TV programming, videogames, and even telephone conversations. The major providers of this segment are the publishing, television, and telecommunications industries, and home electronics manufacturing firms. One other industry is absolutely crucial to this segment—the advertising industry (described in the preceding section of this chapter), which is the central financial mechanism for the creation of television programming.

Arts and entertainment includes all away-from-home entertainment and cultural events. The products are the actual events themselves, as provided by the motion picture, professional sports, music, and other industries. Obviously, this segment is closely linked to the media segment described above, as these arts and entertainment activities are a major source of media programming.

Recreation refers to all outdoor leisure activity that requires the direct participation of individuals or groups, such as camping, sports, and visits to amusement parks. There are two basic categories—the equipment necessary to pursue a particular activity (for example, sporting goods) and the services that make participation possible (campgrounds, amusement parks, parks and recreation facilities, etc.).

Travel and tourism includes all activities related to leisure travel. Some typical products and services are lodging, transportation, and travel agent services.

Civic participation includes all religious, political, professional, and other civic activity that constitutes an important part of an individual's use of free time, as well as involving expenditures. The major service of this segment is the establishment of organizations whose purpose is to facilitate civic activity. In this respect, the key "providers" are membership organizations, such as churches, trade unions, professional associations, and political parties.

Personal Consumption includes all activities that combine the fulfillment of personal needs—such as shopping or eating—with the pursuit of leisure, which are in some sense also part of the Recreation and Leisure amenity. The major providers are the food services, industry, and retail trade. This is another segment where the advertising industry, to the degree that it stimulates personal consumption, plays an important role.

Note: Although these categories constitute a broad definition, they do not cover all recreation and leisure activities, such as the considerable sums spent on illegal substances and activities. Further, some activities, even though not illegal, simply cannot be traced. Collectors of artifacts undoubtedly spend billions annually pursuing their hobbies, but as many hobbyists trade rather than sell on the open market; their considerable economic impact eludes conventional accounting.

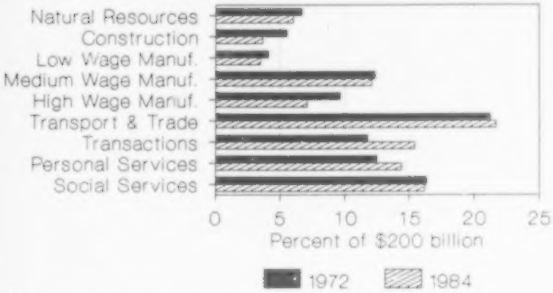
Structure and Performance

The present discussion treats only those parts of the Recreation and Leisure amenity included in the somewhat narrow definition of the sector introduced in chapter 2, which excluded spending on food and domestic travel because it was virtually impossible to distinguish recreational spending from spending for other purposes in these categories. Even using this more restrictive definition of the sector, figure 6-11 suggests that the value-added derived from spending on Recreation and Leisure is spread broadly across the economy. About one-fifth ends up both in manufacturing and in Transportation & Trade. Only 14 percent ends up in the comparatively low-paid Personal Services sector.

Home Entertainment

The underlying economics of home entertainment and home information are difficult to reconstruct, since much of the value of the information received through television, radio, newspapers, and magazines is paid for by advertisers and not directly by consumers. Advertising accounts for 50 to 75 percent of the cost of a delivered newspaper or magazine and nearly 100 percent of the cost of most commercial radio and television. Consumers pay indirectly

Figure 6-11.-Value-Added To Meet Demand for Recreation and Leisure ($200 billion• in 1984)



•Constant 1980 dollars.

SOURCE: Office of Technology Assessment (see table 4-6 of ch. 4).

by the abuse of their patience, and by having advertising costs appear as a part of "transactional" costs throughout the economy. The equation is changing, however, as advertising supported television is replaced by a variety of cable-television options (including pay-per-view technologies), video rentals, and other mechanisms for delivering entertainment software to the home without advertising support. The impact of this change has yet to be felt; advertising revenues of broadcast radio and television remain robust.

Historically, broadcasting has been limited by the availability of usable electromagnetic spectrum. Rather than a local monopoly, the broadcast sector is marked by multiple and roughly equivalent suppliers in a given market. The mode of regulation also differs. Instead of price and rate of return controls, radio and television regulation aims at ownership, program content, and operational controls. Licenses to operate are not granted in perpetuity, but rather are periodically reviewed against a "public interest" standard. Although regulation of telephone common carriage occurs at both the local and Federal level, only Federal regulation occurs for broadcasting. The Communications Act of 1934 specifically defines broadcasting as the "dissemination of radio communications intended to be received by the public, directly or by the intermediatory of relay stations."[224] The Act further distinguishes radio broadcasting as "not . . . a common carrier" activity,[225] and public policy also separates it from "point-to-point" communications.[226]

The Cable Act of 1984 brings cable television under the regulatory auspices of the 1934 Communications Act, while simultaneously relieving the industry of arbitrary franchise, rate, and license renewal requirements imposed by local authorities.[227] One reason for this landmark legislation was that the technology of cable and its market had long ago outstripped the *ad hoc* regulatory framework erected by local, State, and Federal authorities. Among other things, the Cable Act required that basic cable rates be deregulated by 1987, channels be set aside for outright lease to unaffiliated companies, telephone companies not be allowed to operate systems in their regions, cable and broadcast cross-ownership in the same area continue be prohibited, and cable and newspaper cross-ownership be permitted. State regulation of cable companies as common carriers was prohibited.[228] These rules opened the industry to further consolidation and protected it from the advances of stronger telecommunications and broadcast entities seeking to accumulate operating assets across the whole spectrum of the communications and information industries.

There are no legal or regulatory restrictions on the vertical integration of systems operators into programming and distribution under the Cable Act (nor are there restrictions on non-cable entities providing programming services to cable systems, including competitive communications entities). Unlike broadcasters, multiple system operators (MSOs), can control both program content and local cable conduits on a national scale. Many of the top 20 cable origination program suppliers are owned in whole or in part by one or more MSOs. These programming interests are being traded by MSOs in moves to consolidate the now-dispersed program supply within a few entities with financial clout, the cable system outlets, and the system interconnections—all in order to improve the quality of programming and the economic performance of both the programmers and the cable systems.

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[224] United States Code, No. 47, Sec. 153 (o), 1976.

[225] United States Code, No. 47, Sec. 153 (h), 1976.

[226] See "Subscription Television Service,"Federal Communications Commission, No. 3, Sec. 2d-1 (9), 1966.

[227] Cable Communications Policy Act of 1984, PL 98-549 (1984 Amending Communications Act of 1934, 48 Stat. 1064).

[228] "Cable Regulation," *Broadcasting*, July 1, 1985, p. 22.

Concentration of ownership of cable systems is not generally subject to any limitation. In 1980, broadcasters owned 33 percent of all cable television systems in spite of the cross-ownership restrictions. Newspapers and book publishers owned 24 percent and operated under no ownership regulation; television program producers and distributors owned 18 percent. The broad ban on telephone company operation of cable systems included in the Cable Act is an attempt to dampen any anticompetitive practices that could result from a local monopoly telephone company owning a cable television facility in the same community.[229] The telephone company cross-ownership ban does not, however, prevent telephone companies from owning or operating cable television service in any area outside local exchange boundaries.

The bans on network/cable cross-ownership and local broadcast station/cable cross-ownership are clearly designed to insure maximum video program diversity in the local community by limiting the power of the networks to acquire cable operations, which by their very nature compete with network programming and supplement the broadcast of both network and local programming by cable carriage of broadcast signals. These bans are continued by the Cable Act.

As an unregulated industry, printing and publishing has not been affected by the major changes in the rules governing the organization of other media industries. New printing technologies, however, such as those involving low-cost "print-on-demand" techniques and the possible substitution of electronic media for certain kinds of publications, may lead to significant shifts in the industry during the next two decades. These are analyzed in the next section.

The development of standards is critical for moving into advanced communication technologies (see also previous discussion of Personal Business and Communication). It has, for example, proven to be extremely difficult to develop a technology for high-definition television that will not render existing receivers obsolete.

Network Components

The Media.—New electronic technologies have led to rapid growth in sales of audio and video equipment for the home, have resulted in many new channels for delivering software, and have even spawned new industries (i.e. audio tapes, compact disks, video tapes, and cable television). Even newspaper and magazine publications have become more differentiated. On the other hand, it is not clear that this diversity of products and a change in the mix between spending on hardware and software has resulted in a significant change in patterns of ownership.

The film industry illustrates a complex pattern of transformation. The industry is no longer built around the vast, vertically-integrated film studio empires of the "Golden Age" of cinema, but is shifting toward more flexible networks of activities that are in effect satellites of major firms. At one time, seven major studios owned their own theater chains, five of which controlled some 70 percent of first-run capacity in the big-city markets. Each was vertically integrated with their own facilities not only for production but for distribution of entertainment spectacles; they were models of standardized industrial mass marketing.[230] Divestiture of the theater chains in an antitrust settlement in 1948, and a series of changes ranging from the decline of center cities to the emergence of television, helped erode the in-house production structure and paved the way for independent producers.[231] Even the belated effort to acquire TV stations and theaters in the 1980s in order to regain control over the exhibition of their increasingly expensive products seems unlikely to reverse the fragmentation of distribution that makes old-style studio operations impossible.[232] Tasks formerly performed by the studios themselves became more and more contract work assigned to specialists. Almost in spite of itself, the motion picture industry has come to be a model of "flexible specialization."[233]

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[229] Cable operators, it should be recalled, control both the conduit of communication and the content, or programming; telephone companies control only the conduit. Additionally, such cross-ownership would put the telephone company in a conflict of interest position as it negotiated with the cable company for compensation for carriage of the television cable on local utility poles.

[230] Michael Storper and Susan Christopherson, "Flexible Specialization and Regional Industrial Agglomerations: The Case of the U.S. Motion Picture Industry," research monograph, Graduate School of Architecture and Urban Planning, University of California at Los Angeles, February 1986, p. 7.

[231] Michael Storper and Susan Christopherson, "Labor in a Post-Mass Production Industry: The Case of the U.S. Motion Picture Industry," research monograph, Graduate School of Architecture and Urban Planning, University of California at Los Angeles, 1985.

[232] Aljean Harmetz, "Hollywood Seeks Control of Outlets," *The New York Times*, Mar. 3, 1986, p. D1.

[233] See, for example, U.S. Congressional Clearinghouse on the Future, "High-Flex Workers: Adapting to a Changing Economy," in the "Emerging Issues" series, Washington, DC, November 1985.

The motion picture industry has been drawn into the home-media realm, with many productions made exclusively for television use and all made with television ultimately in mind. Some 69 percent of cable subscribers and owners go to movie theaters less than once a month;[234] perhaps half of motion picture revenues now derive from video markets;[235] and VCR rentals may amount to 75 percent of the level of revenues generated by box office admissions.[236] Its new labor arrangements dictate that many of its personnel and facilities work interchangeably in television as well.

The three major television networks continue to dominate national television broadcasting, but changed regulations have fundamentally altered the nature of competition in this industry. In many cases new rules had to be devised to accommodate new forms of broadcast communication, including cable television, multipoint distribution systems, subscription television, direct broadcast satellites, teletext and videotex, and home video services.

Magazine and Book Publishing.—Publishing, once dominated by local papers and broad coverage/national-scope magazines is undergoing two kinds of transformation: newspapers are entering the national market (i.e., *USA Today* and *The Wall Street Journal*), while many cities now lack significant competition in daily papers. On the other hand, "national" magazines have found their markets disappear in favor of more than 11,000 highly differentiated and specialized markets for everything from stamp collecting to yachting.[237] Even magazines serving more generic markets are able to use computer controlled printing systems to specialize their products for local markets. *Business Week*, for example, prepares different editions for different customer classes. Many of the highly specialized publications are, however, owned by large concerns like Time-Life, so that the capacity to mass-market or even reassemble individual general-interest magazines remains more concentrated than a list of titles would lead one to expect.[238] The same network of advertisers and readers, and the same facilities and expertise required to produce any glossy magazine, can be adapted easily to areas of related interest.

The disintegration of the book publishing industry through fragmented market demands has not proceeded nearly as far. Ten American publishers still account for 88 percent of sales. The technological tools now available to publishers—on-line systems, database management systems, and personal computers with "desktop publishing" capability—are available to small firms as well as larger ones, thus checking trends towards consolidation.[239] A rough estimate suggests that the number of book publishers has doubled over the last generation.[240]

Home Electronics.—U.S. firms have all but abandoned the manufacture of home electronic equipment. Virtually all major innovations in video and audio equipment in the past five years (compact discs, video tape recorders, and inexpensive camrecorders) have been marketed by Japanese or other Asian producers. Foreign producers have also made major inroads into the market for professional production equipment (cameras, recorders, editing equipment, and special effects equipment). Foreign command of the industry is likely to continue unabated, because of both an impressive reputation for low cost and high quality and massive investments in research and development. New digital tape systems for sound and video recording, high definition television systems, and a variety of other advanced systems will be produced abroad. Given that capital equipment in the home has come to represent a large share of all spending on home entertainment, this is a serious loss.

New Technologies and System Integration.—Emerging technologies with potential to affect the recreation and leisure economy include cellular mobile telephones and radio paging, compact disks, electronic mail, enhanced television, fiber optics, low-power television, multipoint distribution services, optical video disks, pay-per-view television, personal computers, satellite master antenna television, signal compression, teletex, the video cassette recorder, and videotex. All of these have the potential to enhance and extend leisure activities in the home. They compete not just with one another but with established media for the consumer's money and time. Some of these technologies are almost mutually exclusive, in that their overlapping capabilities make it improbable that all would exist in any given household. Those that survive will depend not upon their technical feasibility but upon their capacity to deliver the services most in demand. (See figure 3-8, p. 139.)

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[234] LINK Resources, "New Media Consumer Survey: Executive Summary" New York, NY, 1984, p. 18, table 13.

[235] Arlene K. Fleming and Robert November, *The Impact of Technology on Home Information, Transactions, and Entertainment*, contract report prepared for the Office of Technology Assessment by LINK, a subsidiary of International Data Corp., June 1985, pp. II.20-21.

[236] "Hollywood Worried by Growing Cassette Rentals," *The New York Times*, Nov. 18, 1985, p. C18.

[237] See S. Fatis (note 20, p. 70).

[238] Arlene K. Fleming and Robert November, op. cit., footnote 235, p. II.47-50.

[239] UNESCO, *The Future of the Book, Part III—New Technologies in Book Distribution: The United States Experience* (Paris: UNESCO, 1984), pp. 27-29.

[240] Dan Lacy, "Publishing Enters the Eighties," pp. 11-25, in U.S. Library of Congress, *The State of the Book World 1980* (Washington, DC: U.S. Government Printing Office, 1981), p. 11.

The spectacular failure of the Keytron videotext venture in Chicago and Viewtron in southern Florida does not seem to have failed to stem interest in the new home information technology. The new investors come primarily from information firms like Reuters, Dow Jones, McGraw Hill, and Dun & Bradstreet, and technology firms like Mead Data Central, Lockheed Corp., Compuserve, and AT&T. These firms have formed interesting corporate alliances to develop home information services:

- Trintex (designed to provide residential videotext, entertainment, and information) = IBM + Sears + CBS;
- Covidea (designed to provide electronic banking and access to public databases) = AT&T + Chemical Bank + Bank of America + Time Inc.;
- IMnet (stock and business data) = IBM + Merrill Lynch; and
- Quotron (stock quotations) = Citicorp.

Away From Home Entertainment

Far from competing with vacation spots, future home travelogues seem more likely to stimulate the desire to visit them. The film *Deliverance* spawned business for white water raft trips and the television production *Love Boat* boosted business for cruise ships.

The discussions of chapter 3 indicated that the annual two-week domestic family vacation is of declining importance in overall demand for recreation. It has been replaced by more frequent short trips close to home, mixed with occasional jaunts abroad or to distant parts of the country. Variety rather than serenity may be the new keynote of travel.[241]

It is not surprising, then, that the President's Commission on Americans Outdoors discovered demand for better outdoor recreation opportunities close to home when it measured public opinion through polls, position papers, and hearings conducted all over the country. What did surprise the Commission staff was the extent of this demand: in all sections and demographic groups it was overwhelming.[242]

People pressed for time necessarily seek diversions which are close at hand, whether indoor or outdoor, organized or informal, commercial or public. People who live near bowling alleys are most likely to learn how to bowl, while those with convenient access to lakes or pools more probably improve their swimming. To erode dwindling recreation time further in traveling to facilities is vexing to many Americans. Economists estimating the impact of outdoor recreation have realized that omitting travel time from the travel cost method creates a "substantial downward bias" in figuring benefits; a 30 percent allowance for it is taken to be conservative.[243]

Network Components

Getting There.—Patterns of change affecting the entire U.S. travel industry were discussed earlier in this chapter. The factors reshaping the travel agency businesses, however, reflect many forces unique to recreation industries. In the mid-1980s, the 20,000 American travel agencies with their 6,000 branches constitute an industry growing by about 10 percent annually. Countering this expansion is a trend toward consolidation, as smaller agencies merge or are acquired by larger ones enjoying the benefits of mass discounts and more sophisticated automation.[244] The industry expects to flourish by emphasizing its knowledge resources as opposed to a mere ticket-selling.[245]

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[241] An interesting European perspective is that of Markus Schwaninger, "Forecasting Leisure and Tourism: Scenario Projections for 2000-2010," *Tourism Management*, December 1984, pp. 250-57.

[242] Conversations with Barry S. Tindall, associate director, and Michael P. Rogers, staff associate, of the President's Commission on Americans Outdoors, autumn 1986. The Commission staff generously allowed OTA access to its hearing transcripts, literature review papers, and other data; the conclusions drawn here are, however, those of OTA.

[243] Cindy F. Sorg and John B. Loomis, *Empirical Estimates of Amenity Forest Values: A Comparative Review*, U.S. Department of Agriculture, Forest Service General Technical Report RM-107, Fort Collins, CO, March 1984, pp. 2-3.

The pressures on the travel agents come from several directions. The fear that consolidation will allow just five or six carriers to control 90 percent of air travel implies further domination by those carriers of the travel agents who depend on their business. Reduced services and commissions by the airlines are one prospect. Another is that as services now performed for free become increasingly expensive, their costs will have to passed along to the customer, weakening the economic argument for employing a travel agency. There is also some feeling that ticketing errors and other common mistakes must be reduced if a consumer rebellion against travel agents is to be avoided.

Lodging.—The 1982 Census of the Services Industry by the U.S. Bureau of the Census identified 41,231 establishments in the tourism industry, divided among hotels, motels, and tourist courts; rooming and boarding houses; camps and trailering parks; trailering parks for camp sites for transients; and organization hotels and lodging houses. These employed over 1.1 million persons with an annual payroll of $9.3 billion and receipts of $33.2 billion; 35,030 of these businesses fell in the hotel-motel-tourist category.

The dynamics of change in the "hospitality industry," as it styles itself, are evident. As a leading industry observer, Albert J. Gomes, concludes, it is offering an increasingly diversified product even though the ratio of one hotel room per 100 Americans has been "remarkably constant" for half a century.[246] One hint that greater differentiation is taking place is increasing prominence as a source of revenues of miscellaneous "other" categories, as opposed to room rents and food-and-drink costs. Room rents accounted for 61.5 percent of hotel revenues in the 1972 *Census of Service Industries*, 60.5 percent in 1977, and only 57.8 percent in 1982; food and drink slipped from 21.7 percent in 1972 to 20.4 percent in 1977 to 18.8 percent in 1982; but "other" sources of revenue, including entertainment and amenities of various sorts, swelled from 6.3 percent in 1972 to 8.6 percent in 1977 to 13.8 percent in 1982. Although some of the reduced food costs represent the inroads independent restaurants have made in attracting the hotel guest's business, the growing importance of other amenities seems clear. Likewise, the usually cheaper, less differentiated roadside motels peaked at 62.1 percent of the market in 1972, splitting with hotels after years of steady increase, and declined to 59.9 percent in 1977. Reflecting the generally lower prices of motels, the decline in their receipts was even more pronounced during this period, going from 52.5 percent to 44.2 percent.[247]

Since the 1982 survey, a difficult-to-measure, literally "cottage industry," the bed-and-breakfast (B&B) house, has grown phenomenally. It may be viewed in the context of consumer desire for differentiated accomodations. In picturesque tourist destinations, attractive or historic homes furnished with period antiques often exceed the rates of nearby hotels; in large cities, on the other hand, such accomodations may cost a fraction of the price of a convention hotel. Because these informal, owner-operated establishments rarely belong to trade organizations and often advertise solely by word-of-mouth, it is difficult to calculate their numbers or economic impact in the leisure economy; a 1986 directory lists some 200 reservation services representing 15,000 B&Bs nationwide.[248] Many others doing business largely or entirely by word-of-mouth probably swell the total. Clearly the 1982 industry census does not reflect the recent B&B phenomenon, which could have a significant impact throughout the sector.

Specialized packaging of American accomodations, whether for senior citizens, art lovers, or people traveling with pets or children, could flourish in the United States; in fact, a proposal to open a resort perceived as catering to homosexuals has generated controversy in Las Vegas and Ft. Lauderdale. Realizing that they yield a higher profit margin than group

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[244] For industry trends, see *Travel Weekly*, Louis Harris Study Issue, 1984; and Mary J. Pitzer with Richard W. Anderson, "Mega-Agencies Are Gobbling Up the Travel Business," *Business Week*, No. 2910, Sept. 2, 1985, pp. 56-57.

[245] Interview conducted for OTA by the Institute for Career and Leisure Development with D. Minic, Director of Public Relations, and Julianne Johnson, Director of Membership Services, American Society of Travel Agents, May 2, 1985.

[246] Albert J. Gomes, *Hospitality in Transition: A Retrospective and Prospective Look at the U.S. Lodging Industry* (Washington, DC: American Hotel and Motel Association, 1985), p. 53.

[247] See Gomes, op. cit., footnote 246, pp. 24, 57-58.

[248] Bernice Chesler, *Bed & Breakfast Coast to Coast* (Lexington, MA: Stephen Greene Press, 1986).

guests, the Tokyo-based Hotel New Otani chain courts individual visitors through a card-holding membership system that involves amenities like room discounts and checkout time extensions;[249] American lodgings could eventually reverse their traditional disincentives to lone travelers on the same basis. There is already some effort by the larger lodging chains to address market diversification at least on the economic level; Holiday Inns have inaugurated a line of inexpensive Hampton Inns, evocative of the small, family-run motels of the 1950s and 1960s.[250] This response to market segmentation, called "tiering," by levels of price and facilities, has made the new budget motel operations the fastest-growing segment of the industry; a form of do-it-yourself tiering has also occurred, in which two couples will split the costs of the new residential-suite lodges, with which consumer satisfaction is high.[251] The success of a non-smokers' motel near Texas Stadium, evocative of the old "temperence hotels" that once catered to teetotalers, could herald a health-oriented trend among many specialized markets.

Destinations.—Recent predictions of national homogenization by means of the mass media seem to be giving way to a tide of celebration of what is unique in many areas of our land. State and regional fairs thrive, while the development of local opera and theater companies produces a measurable increase in attendance at live performances.[252] Even the newfound vitality of museums in America's cultural life has been attributed to revitalized local institutions.[253] Regionally oriented publishing has come into its own, while local or regional food events like Mississippi catfish carnivals or the "Memphis in May" National Barbecue Festival draw national and even international participants. For the tourist economy, the more an area's particular assets are developed and publicized, the greater its potential as a destination. This new American regionalism may flourish, with benefits to the American tourism economy.

Older resorts cannot depend upon steady business when new or revitalized competitors lure their business away. Decline can be sudden. In 1982, 67 percent of visitors to Virginia Beach, VA were repeat vacationers; by 1984 the resort area enjoyed 64 percent repeat business, and by 1986 just 43 percent. Although the decline is in some degree related to a dip in tourism in the immediate region, the lack of a strong, coordinated effort to enhance Virginia Beach as a vacation spot and the nostalgic reliance on the old-fashioned, two-week family vacation seems to mandate quick action if the old resort is to avoid economic decline.[254] This and other older tourist magnets will have to feature their unique amenities if they are to draw affluent vacationers.

Intrinsic tensions have always separated groups interested in the preservation of nature and those interested in making a profit from outdoor activities. There are, however, many places where the interests of these groups converge. Preserving America's heritage as a travel destination can yield many common benefits.[255] For forest-related activities, studies from several States have been gathered in their discussion of methodology to determine economic benefits. The adjusted values for camping, converted to 1982 dollars, ranged from a low per activity day of $5.80 to highs of $26.18 and $26.35.[256] Cold water fishing ranged from $8.58 to $67.55, and hiking from $8.25 to $45.76[257] Obviously, the variance of these diverse estimates owes much to the varying methodology.

Unfortunately for park authorities, the economic benefits of natural areas are generated indirectly. In time, pressure on natural resources such as wildlife refuges to justify themselves in thoroughly inappropriate cost-benefit terms can produce incompatible uses and destructive pressures that damage their intrinsic value.[258]

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[249] *Mitsubishi Bank Review*, vol. 17, No. 1, October 1986, p. 989.

[250] Phil Patton, "America's Home Away From Home Is Still a Good Motel," *Smithsonian*, vol. 16, No. 12, March 1986, p. 127 ff.

[251] *Consumer Reports*, No. 477.

[252] Linda Deekard, "Good Year for Fair Industry Despite Economy, Insurance," *Amusement Business*, vol. 27, December 1986, p. 1, reports that the top fifty North American fairs drew 47,204,576 during that year; information on increased patronage of museums and cultural events derived from the *Statistical Abstract of the United States 1987*, op. cit., footnote 128.

[253] Interesting perceptions that the "arts have reached mainstream status in communities around the country" appear in Anne E. Abramson, "Dear Readers," *Museum and Arts Washington*, Jan.-Feb. 1987, p. 4.

[254] Gerri Willis, "Resort at Risk," *Virginian-Pilot*, Aug. 9, 1987, p. E1, offers a model analysis of an aging resort's problems.

[255] The "Focus on Tourism" issue of the National Recreation and Park Association's *Parks & Recreation* vol. 21, No. 10, October 1986, reflects the trend.

[256] Sorg and Loomis, op. cit., footnote 243, p. 8.

[257] Ibid., pp. 11-15.

[258] Jim Doherty, "Refuges on the Rocks," *Audubon*, vol. 85, July 1983, pp. 74-116.

In such an environment, the consumer wins a better product—a better physical environment, a more comprehensive recreation program, and more effective fitness instruction—at higher cost. In the public sector, there is evidence that Americans are willing to pay a price. The (arguably leading) questions in the *1982-1983 National Recreation Survey* arrived at conclusions much in keeping with other opinion surveys in recent years: "a preference for cost sharing of visitor service expenses [between taxes and user fees] is very widespread among the public."[259] Indeed, Americans seem willing to contribute toward such purposes; for instance, in 1985 recipients of Michigan State tax refunds checked off $500,000 alone to aid in restoration of nongame wildlife.[260] It is likely that this kind of funding will increase.[261]

In the private sector, a mass economy/individualized economy dichotomy is likely to emerge. YMCAs, YWCAs and community centers appear to be in great demand to meet popular desire for physical fitness instruction and facilities, while posh exercise salons or specialized martial arts studios will cater to those who can afford more personalized attention. Exotic thrill sports, ranging from hang gliding to adult wargaming, constitute a continuing element of the upscale consumption.

Transportation as a Destination.—Those who flock on board Amtrak's excursions across the continent would hardly endure the same journies on board the slow, jolting, sooty railcars that carried previous generations of travellers. The Norfolk and Southern railroad offers air-conditioned luxury cars as well as old-fashioned ones on its steam train excursions, a concession to those who temper their nostalgia with a concern for comfort.

The American cruise industry, ranging from the steamboat trips down the Mississippi to the island-hopping Carribbean liners popularized by the television series "Love Boat," appeals to the revived notion of transportation as destination. Few customers have the resources of money and leisure to take the leisurely world cruises of the past; to appeal to the many who would sample the tranquility of shipboard life, shorter packages have emerged. The logical extreme, "cruises to nowhere," where the sensations and amenities are themselves the attraction, dispense with destination entirely.

New Technology and System Integration.—Technology poses new challenges for integrating the diverse set of activities involved in away from home recreation. The travel industry has taken major steps to integrate transport and lodging reservations. Airline reservation systems, developed with the help of regulated air rates, provide a powerful tool for facilitating air travel. It has proven difficult for any new system to compete with those already in place given the economics of an unregulated industry. Travel agencies have improved their ability to arrange accommodations around the world. New systems would permit a greater variety of small facilities to be a part of such systems. The automated teller machine systems described in the section on Personal Business and Communication are being expanded to provide consumer entry points into reservation systems, and to sell tickets for transportation, theater, and sporting events. American Airlines has 5,000 terminals for dispensing tickets in travel agencies. Avis handles some rental returns through terminals.[262] In the future, such systems could let prospective clients do more "shopping" for destinations of interest through interactive video systems.

The venerable Thomas Cook agency now uses an "expert system," capable of answering "quite complicated questions about how best to achieve certain [travel] objectives, and all large agencies stand to benefit from the improved reservation systems present and potential."[263] However, technologies that can reduce costs and errors for the travel agent may also be employed directly by the consumer. The French Minitel system, discussed in the preceding section of this chapter, allows inhabitants of the most remote villages not just abundant information about transportation and lodging throughout the country, but also the capacity to make and pay for reservations. Likewise, passengers may walk into the railroad station in Lyons and ticket themselves directly onto the TGV to Paris through an easy-to-use and polite computer; Amtrak has introduced such vending machines in the United states as well. Thus some of the routine business of the travel agent is bypassed.

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[259] *1982-1983 National Recreation Survey*, pp. 43-44, 63-65.

[260] *Michigan's Environmental Quality: 1985* (Lansing, MI: Michigan United Conservation Clubs, 1985), p. 5.

[261] See Derrick A. Crandall, "Recreation on Public Lands: Should the User Pay?" *American Forests* vol. 90, March 1984, p. 10, for important caveats.

[262] B. Rosenberg, "Money Machines Outgrow Banking," *High Technology Business*, vol. 7, No. 10, October 1987, pp. 34-37.

[263] *Tourism Management*, vol 7, No. 1, March 1986, p. 143.

Business already has access to travel information in a number of ways, including SiteSelex On-Line, a videotex service offering subscribers information on 6,000 hotels, resorts, and conference centers.[264] More comprehensive services are also emerging with some access for the general public. The National Tourism Data Base program, initiated in 1985 by the U.S.Conference of Mayors, could grow into the basis for improved services by travel agents to their clients; yet it could grow beyond that level to direct interation with consumers themselves.[265] Already some 21,000 travel agencies—85 percent of the automated agencies in the country—are able to supply Data Base information free to their customers. Offices of the U.S. Travel and Tourism Administration make the Data Base available to foreign inquirers.

The National Tourism Data Base is not now interactive, and it is too early to tell how successful the effort will be. At present, its strength is specificity; it offers the hours, admission charges, descriptions, and telephone numbers of perennial attractions such as the Washington Monument, and more importantly the relevant data on ephemeral events, such as concerts, so that travelers may plan ahead and arrange for tickets difficult to obtain at the last minute. Thus a traveler planning to visit a participating city such as Anchorage, Alaska, is better able to take advantage of current goings-on as well as the city's regular attractions.

Automated on-site terminals already provide one alternative means of informing visitors. For instance, Baltimore has installed INFOTOUCH, "the new, touch-screen City Directory System . . . housed in attractive, easily-recognizable kiosks" at seven visitor sites around the city—"offering a series of menu-driven screens, Infotouch highlights all of Baltimore City's attractions, events, dining, shops, services, and more with colorful, exciting, high-resolution graphics."[266] Listings are available in various categories to advertisers for origination fees plus varying monthly rates.

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[264] *American Printer*, November 1986, p. 18.

[265] Brochure, U.S. Conference of Mayors, June 1986; American Airlines news release, Apr. 23, 1985; Robert Loomis, "Check Citilog for 'After Business' Activities," *Online Today*, April 1986, p. 19; conversation and system demonstration with Monica Harvey, National Tourism Data Base, Nov. 13, 1986.

[266] Brochure, Info Corporation, Baltimore, MD.

MANUFACTURING

Many studies of innovation in manufacturing have been published during the past few years.[267] Many of the issues have already been discussed in connection with specific amenity networks examined earlier in this chapter. While it is not useful to repeat these discussions, the following section will review some common themes: movement toward smaller, more flexible manufacturing establishments, reduced use of energy and materials, and increased use of automated production equipment and intermediate inputs of "services."

Factors Forcing Change

Manufacturing enterprises in the United States are comparatively free of government control. Their behavior, therefore, is presumably described relatively well by microeconomic analysis. A number of informal institutional constraints, however, often block effective competition. Some of these involve rigidly hierarchical and often insular bureaucratic structures within large organizations. Some involve longstanding ties between vendors and relatively small purchasers of capital goods. Some are purely matters of personality and "old-boy" networks perpetuated by regular contacts.

The flow of information and real decision-making authority through manufacturing systems is poorly doucumented and poorly understood. Most decisions about technology are made in response to advice from capital goods suppliers, specialty products manufacturers, or "turn key" engineering firms. Occasionally, research problems are contracted out to independent research laboratories such as the Battelle Memorial Research Institute, SRI International, the Midwest Research Institute, or the Southwest Research Institute.[268]

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[267] The theoretical literature is reviewed in L. Tornatsky et al., *The Process of Technological Innovation: Reviewing the Literature* (Washington, DC: National Science Foundation, 1983). Two OTA studies have also surveyed the literature in technology and manufacturing in some detail: *Computerized Manufacturing Automation*, OTA-CIT-235 (Washington, DC: U.S. Government Printing Office, April 1984), and *Technology and Structural Unemployment: Reemploying Displaced Adults*, op. cit., footnote 163.

Many traditional forms of regulation have come under intense assault from both foreign competition and the opportunities created by new technology. While the quality of management in U.S. manufacturing may not have grown noticeably worse in the past two decades, U.S. management is being tested in unprecedented ways. Management structures that worked well in an era where domestic markets were highly predictable, or could be manipulated in ways that would make them predictable, may not be well suited to an era of uncertainty and a lack of control over international markets.[269]

Rigid hierarchical firms, and those governed by rigid cost-benefit formulae, tend not to make innovations in production techniques. Greater uncertainty may accentuate the rigidity of these organizations rather than force them into more creative management practices. For example, a survey of producers of automobile parts, agricultural machinery, and pumps and compressors found that the 26 firms using advanced production equipment tended to have less centralized management, a general manager with broader authority and more technical background, and a recognized long-term planning program.[270] Financial managers located in distant "front offices" were viewed as a major barrier to innovation.

The precise costs and benefits of a new technology are virtually impossible to quantify to the satisfaction of most financial analysts, few of whom have any direct experience in the engineering details of manufacturing. By the time such numbers can be developed with precision, the concept has had many years of reliable field experience and is no longer an "innovation." This difficulty is compounded by the fact that many of the advantages of new production technology cannot be captured in a simple analysis of internal rates of return, typically designed only to highlight the advantages of systems for reducing direct labor costs.

As with all the business networks explored in this chapter, the full advantages of production technology can seldom be captured without a far-reaching review of the way production is managed and the way employees are integrated into the process. A major automobile manufacturing firm recently discovered that a change in management and incentive systems in an older plant led to rapid growth in productivity, while a massive investment in new technology not accompanied by changes in the relationships between workers and line management fell far short of productivity goals.[271]

The problem is further exacerbated by the fact that the production workers and personnel in manufacturing typically do not have much "clout" in the hierarchies of large companies in comparison with marketing or financial staffs. In extreme cases, a manager may believe that expensive innovations in manufacturing technology are simply forbidden by a rigid and fixed budget to cover replacements of capital equipment. The survey described above identified several cases where outside consultants were hired to push a new idea within a firm because outsiders could make a better case to the financial experts in the firm.

Scale and Scope

The impact of tightly integrated production networks, described repeatedly in earlier sections of this chapter, are having dramatic—although sometimes contradictory—effects on the structure of U.S. manufacturing enterprises. Demand for timely delivery, reliable quality, and exacting tolerances are forcing many production firms to purchase more sophisticated equipment and adopt new techniques of organization. This may make it easier for relatively small firms to participate in a dynamic production network.[272]

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[268] Mary M. Watkins (ed.), *Research Centers Directory* (Detroit, MI: Gale, 8th Edition).

[269] W.J. Abernathy et al., *Industrial Renaissance: Producing a Competitive Future for America* (New York, NY: Basic Books, 1983).

[270] Carol Parsons et al., "The Development of Programmable Automation Systems in Discreet Parts Manufacturing Industries," contract report prepared for the Office of Technology Assessment, Washington, DC, 1984.

[271] W. Hampton and J.R. Norman, "General Motors: What Went Wrong," *Business Week*, No. 2990, Mar. 16, 1987, p. 102.

[272] Michael Piore and Charles Sable, *The Second Industrial Divide* (New York, NY: Basic Books, 1984).

The widespread application of microchip-based technology has fundamentally altered previous notions of scale and scope for American businesses. The availability of inexpensive Computer Assisted Design (CAD) and Computer Assisted Manufacturing (CAM) technologies that run on personal computers has allowed even small machine shops to adopt this technology, reducing waste, errors, and down time. The time required from receiving a customer's drawing to cutting a die has been reduced by a factor of seven.[273] Metal fabrication facilities that formerly required large staffs, fixed automation, and long production runs can now make use of technologies such as flexible manufacturing systems (FMS) that used to be the sole preserve of large businesses. Minimum efficiency can now be achieved with six machines and six people.[274]

Smaller firms, however, often cannot afford the more complex automated equipment and the associated personnel needed to meet the demanding tolerances and schedules, and are turning instead to the highly competitive "aftermarkets." In the case of agricultural parts production, computer controlled equipment allowed at least one major supplier to survive the recession by competing successfully with highly specialized local producers. The firm relied on low-cost production using conventional manufacturing technology, in addition to a knowledge of niche markets and traditional relationships.[275]

At a broader level, chapter 5 presented data that indicated that manufacturing firms were increasing their scope through ownership of a more heterogeneous collection of manufacturing establishments, but that the establishments themselves were becoming more specialized.

Recipe Changes

While significant progress has been made through a workman-like accumulation of incremental improvements, the past few years have also witnessed a series of breakthroughs that change the product and the production process in fundamental ways. The manufacture of float-glass is one such example —it reduced capital, labor, and materials costs simultaneously while improving the quality of the product. In the production of metal parts, advances that reduce the total number of components needing assembly can be as important as techniques for improving the productivity of making each part. In addition, converting to alternative materials (powdered metals, plastics, or composites) can radically change the manufacturing process and render traditional metal forming processes irrelevant.[276] There are also synergistic effects. New components once requiring the assembly of several parts can be produced in a single step. Helicopters made from advanced composites, for example, can be assembled from 1,500 parts instead of the 11,000 needed for conventional manufacture; the number of fasteners is reduced by 90 percent.[277]

While new manufacturing technologies represent a diverse collection of innovations, taken together they appear to offer the following advantages:

- sharply increased labor productivity,
- declining economies of scale in production,
- increased precision and reliability,
- reduced costs in design and setup,
- increased ability to substitute materials based on cost and performance,
- more efficient utilization of energy and materials,
- more efficient use of manufacturing space, and
- reduced inventory.

An ability to adapt quickly to changing domestic and international market conditions, and to unanticipated changes in the costs of materials, has become critical for many manufacturing firms. Rapid response and controlled inventory networks emerging throughout the country are demanding such flexibility. Even firms not closely tied to such networks find that long-term survival depends on adaptability.

New manufacturing equipment, such as numerically controlled machine tools (NCMTs), robotics, CAD, and automated delivery and transport systems, play a key role in increasing flexibility and productivity.[278] For example, by coupling several of these technologies together into an FMS, GE has been able to cut the cycle time of production of locomotives down from 16 days to 16 hours.[279]

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[273] *Mechanical Engineering*, January 1987, p. 6.

[274] Ramchandran Jaikumar, "Postindustrial Manufacturing," *Harvard Business Review*, vol. 86. No. 6, November/December 1986, p. 76.

[275] C. Parsons et al., op. cit., footnote 270.

[276] Robert H. Williams, Eric D. Larson, and Marc H. Ross, "Materials, Affluence, and Industrial Energy Use," *Annual Review of Energy*, No. 12, 1987, pp. 99-144.

[277] R.C. Forney, "Advanced Composites, the Structural Revolution," *Journal of Metals* vol. 38, No. 3, pp. 18-20, cited in R.H. Williams et al., op. cit., footnote 276.

[278] John Ettlie, "Facing the Factory of the Future," Industrial Technology Institute Working Paper, unpublished, August 1984, p. 2.

The potential of these advanced manufacturing technologies is further enhanced when used in combination with new materials requiring significantly simpler production strategies. There are indications that plastic-forming tools can be operated economically with far shorter production runs than typical steel stamping equipment in the production of products like automobile fenders.[280] Through use of advanced manufacturing technologies and new materials, the recipe of production can be radically changed.

The advantages of new, flexible production equipment depend critically on the number of identical units being produced. If parts must be made in extremely small numbers it is typically cheaper to make them by hand using conventional machine tools. If there is a predictable demand for many hundreds of parts each year (as in automobile production, small appliances, or telephone handsets), it is usually desirable to build a plant dedicated to "mass production." On the other hand, when demand is between 10 and 300 large, complex units (i.e., marine engines, large electric motors, and tractors), or between 300 and 15,000 simple parts, it is becoming attractive to use tools that can be flexibly programmed for limited runs. In 1980, between 60 and 80 percent of the value of all machining operations was produced in this intermediate range of production runs.[281] While statistics are poor, anecdotal evidence suggests that the share of production value in these intermediate or "batch" production regimes is increasing.

Inventory control and quick response networks place increasing burdens on producers. The textile and apparel network (described in the discussion of the Clothing and Personal Care network earlier in this chapter) provides a good example.[282] The shortening of the cycle time makes the contracting firm more dependent on suppliers, while simultaneously making the firm more flexible because it no longer has to undertake the function performed by the supplier. Chrysler attributes this increased use of suppliers as the primary factor behind both quality improvements in production and a 50 percent reduction in engineering costs.[283]

Probably the most significant "recipe" change that must accompany the implementation of these new procedures and technologies involves changes in the size, composition, and use of the U.S. work force (a topic covered in more detail in chs. 10 and 11). Workers are less likely to be physically manipulating machine operations, and more likely to be monitoring several machines.[284] The resultant skills demanded become more cognitive and conceptual, rather than perceptual-motor—placing demands on firms to upgrade employees' skills and knowledge. In the few instances where a true FMS has been set up, the manpower savings have resulted in a realignment of skills: in one instance, production workers outnumbered engineers by 22 percent under a conventional production process whereas engineers outnumbered production workers by a factor of three under an FMS configuration.[285] This increased dependence on human capital was also reflected in a survey of the member companies of the National Electrical Manufacturers Association that identified "lack of staff knowledge" as the major obstacle to implementing advanced manufacturing technologies.[286]

Unlike conventional machine tools, programmable manufacturing equipment cannot simply be purchased and turned on. The sophistication of many of these advanced manufacturing technologies requires that machines be tailored to a specific process, creating an idiosyncratic and unpredictable implementation procedure that necessitates a high level of technical expertise. Manufacturers, especially small- and medium- size ones, frequently lack the necessary technical resources to adopt and adapt technology to their needs.[287] Thus, even if a company has access to pertinent information, the information is largely useless without the capability to adapt that information to its situation.[288]

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[279] Ibid., p. 4.

[280] J.P. Clark and M.C. Flemings, "Advanced Materials and the Economy," *Scientific American*, vol. 255, No. 4, pp. 51-57.

[281] Machine Tool Task Force, *Technology of Machine Tools*, October 1980.

[282] Robert M. Frazier, op. cit., footnote 148.

[283] Elizabeth A. Haas, "Breakthrough Manufacturing," *Harvard Business Review*, vol. 87, No. 2, March/April 1987, p. 79.

[284] L. Hirschorn, *Beyond Mechanization* (Cambridge, MA: The MIT Press, 1984).

[285] R. Jaikumar, op. cit., footnote 274, p. 73.

[286] National Electrical Manufacturers Association, "Summary Report for the Automated Systems User Survey of NEMA Membership," Washington, DC, 1984.

[287] David H. Swanson, "Research Needs of Industry," *Journal of Technology Transfer*, vol. 9, No. 1, 1984.

Network Components and Productivity Change

Energy

New technologies have had the effect of greatly reducing demand for materials per unit of output in manufacturing. Higher energy prices led industry to discover a remarkable series of technologies capable of reducing energy inputs.[289] Between 1974 (the first oil embargo) and 1981, fossil fuel energy used per unit of output in manufacturing declined 20.5 percent. The rate of improvement in fossil fuel energy efficiency was twice the rate experienced between 1967 and 1974. Some of the improvement resulted from structural shifts within manufacturing, which moved the industry away from energy-intensive industries (like steel) and toward products requiring fewer energy inputs per unit of output (like semiconductors). About 66 percent of the post-embargo change in the energy/output ratio, however, resulted from real improvements in production efficiency within each industry. About 27 percent of the shift was attributable to a decline in the materials-intensive manufacturing industries.

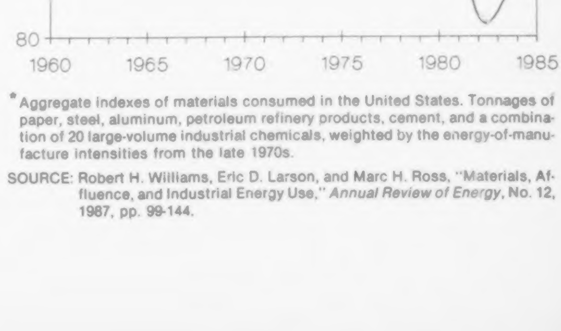
Trends in the use of electricity are much different. The electricity used per unit of output in manufacturing has actually increased slightly since the 1974 embargo. Sectoral shifts that led to a decline in industries using a comparatively large amount of electricity per unit of output were offset by increases in electricity use in individual industry sectors. This indicates an overall shift from fuel to electricity as a manufacturing energy source.[290] As electricity represents only about one-third of the primary energy consumed by U.S. industry, net energy use has fallen since the embargo.

Materials

Material usage per unit of output has also fallen rather steadily. Figure 6-12 indicates that the weight of material needed per unit of U.S. economic output has fallen substantially since the mid 1970s while demand per person has remained roughly the same. Several factors have been suggested to explain this change:[291]

- **A Substitution Effect.** Development of higher strength-to-weight plastics, composites, and other materials allows substitution for steel in applications ranging from packaging materials to aircraft parts, and can reduce the weight of material needed for a variety of functions. The comparatively high cost per pound of new materials can often be justified by their unique strength and other properties. For example, a turbocharger rotor made of ceramics may weigh only one-third as much as a metal rotor.[292] One estimate suggests that by the year 2000, U.S.

Figure 6-12.-Materials Use in the U.S. Economy (indexed pounds per dollar of GNP, 1967=100)*



*Aggregate indexes of materials consumed in the United States. Tonnages of paper, steel, aluminum, petroleum refinery products, cement, and a combination of 20 large-volume industrial chemicals, weighted by the energy-of-manufacture intensities from the late 1970s.

SOURCE: Robert H. Williams, Eric D. Larson, and Marc H. Ross, "Materials, Affluence, and Industrial Energy Use," *Annual Review of Energy*, No. 12, 1987, pp. 99-144.

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[288] Thomas J. Allen, *Managing the Flow of Technology* (Cambridge, MA: The MIT Press, 1977).

[289] Robert H. Williams, Eric D. Larson, and Marc H. Ross, op. cit, footnote 276.

[290] G. Boyd, J.F. McDonald, M. Ross, and D.A. Hanson, "Separating the Changing Composition of U.S. Manufacturing Production from Energy Efficiency Improvements: A Divisa Index Approach," *The Energy Journal*, vol. 8, No. 2, 1987, pp. 77-96.

[291] E.D. Larson, R.H. Williams, and A. Bienkowski, "Material Consumption Patterns and Industrial Energy Demand in Industrialized Countries," Princeton University, Center for Energy and Environmental Studies, PU-CEES Report No. 174, Princeton, NJ, 1984.

[292] R. Williams, et al., op. cit., footnote 276.

demand for polymer composites will reach $12 billion.[293]

- **Changes in Product Mix.** Manufacturing growth has tended to emphasize sophisticated products with relatively high value-added to weight ratios, such as electronic equipment, instead of products with relatively low value-added to weight ratios, such as heavy lifting equipment. For example, $1 of electronic computing equipment uses one-quarter as much steel and two-thirds as much aluminum as the production of $1 worth of machine tools.[294]
- **Redesign of Products.** The average U.S.-made car weighed about 3,800 pounds in 1975 but only 3,230 pounds in 1985; iron and steel weight dropped from 2,500 to 1,760 pounds during the same period. Industry experts expect the weight of an average car to fall to 2,350 pounds by 1992 with total iron and steel weight falling to less than 1,400 pounds.[295]

About one-fifth of all the aluminum consumed in the United States is used in cans. Thinner sidewalls reduced weight by 22 percent and better top designs reduced the weight of lids by 13 percent during the past two decades.[296] Total per capita consumption of metals like copper, lead, zinc, manganese, chromium, nickel, tin, molybdenum, titanium, and tungston has declined in spite of new demands. The decline results both from reduced demands for steel (where the metals were used for alloys) and from better designs in products ranging from batteries to die castings.

In spite of the information and packaging explosion, paper demand per unit of output in the economy has continued to decrease.

Services

The growing links connecting service and manufacturing firms was described at some length in chapters 4 and 5. This, coupled with the complex pattern of mergers and acquisitions that have taken place in the industry, makes it difficult even to define a "manufacturing firm." By 1984, twelve percent of the employment of firms categorized as "manufacturing" was in establishments which were not classified as manufacturing. Non-manufacturing establishments, owned by manufacturing firms, had an employment growth rate of six percent between 1982 and 1984, compared to a loss of one percent in the manufacturing establishments.[297]

As described in chapter 4, the role of services in the production recipe of manufacturing has expanded significantly since 1972. Embedded within many manufactured products are intermediary service inputs. For example, the Office of the U.S. Trade Representative estimates that 80 percent of the value embedded in a computer is in fact a service product: software.[298] Many of the inputs to the new advanced manufacturing technologies being used to modernize industry are also service products, such as CAD software, machine cell design and integration, and data processing services. Many "service" businesses in the United States depend heavily on the fate of the U.S. manufacturing sector.[299]

Net Changes in the Production Recipe[300]

The changes just described are summarized in Table 6-10 which shows how productivity growth in manufacturing can be credited to different factors. Labor productivity led all advances, but its contribution declined considerably during the past 15 years. The productivity with which materials are used in manufacturing continues to increase, although the rate of improvement has also declined in recent years. Energy productivity, which had been

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[293] U.S. Congress, Office of Technology Assessment, *New Structural Material Technologies: Opportunities for the Use of Advanced Ceramics—A Technical Memorandum* (Washington, DC: U.S. Government Printing Office, September 1986).

[294] U.S. Input/Output tables for 1977, cited in R. Williams et al., op. cit., footnote 254.

[295] E. Larson et al., op. cit., footnote 291.

[296] Ibid.

[297] Marjorie Odle and Catherine Armington, "Is American Manufacturing Creating Jobs Again?" unpublished working paper, Applied Systems Institute, Washington, DC, p. 3.

[298] U.S. National Study on Trade in Services, Office of the U.S. Trade Representative, December 1983.

[299] Steven S. Cohen and John Zysman, "The Myth of a Post-Industrial Economy," *Technology Review*, February/March 1987, p. 33.

[300] This analysis is based on the Multifactor Productivity Series, 1949 to 1983, developed by the Bureau of Labor Statistics, U.S. Department of Labor, unpublished, 1986. See William Gullickson and Michael J. Harper, "Multifactor Productivity Measurement for Two-Digit Manufacturing Industries," presented at the Western Economic Association meetings in San Francisco, CA, July 1986, p. 48; and Michael J. Harper and William Gullickson, "Cost Function Models and Accounting for Growth in U.S. Manufacturing, 1949-83," paper presented for the American Economic Association, New Orleans, LA, Dec. 28-30, 1986.

Table 6-10.—Contributions to Productivity Change in Manufacturing, 1949-83

Factor	Average percent change in single-factor productivity[a]			
	1949-65	1965-73	1973-83	
Capital	0.80	−0.70	−2.90	
Labor	2.70	2.70	1.60	
Energy	−1.20	−0.10	1.40	
Materials	1.30	0.70	0.40	
Services	−1.10	−1.30	−1.90	
Multi-factor	2.90	1.90	0.50	
Factor shares of gross output[b]	1949	1965	1973	1983
Capital	0.220	0.232	0.187	0.162
Labor	0.418	0.453	0.468	0.428
Energy	0.019	0.020	0.022	0.044
Materials	0.289	0.218	0.233	0.262
Services	0.054	0.076	0.090	0.104

[a] "Single-Factor Productivity" measures the change in dollars of output in an industry resulting from a $1 increase in the factor purchased (capital, labor, energy, materials, services). The statistic shown in the annual percent *change* is this productivity averaged over the time-periods shown.

[b] The "Factor Share of Gross Output" is a measure of the extent to which a change in an input to the production process (capital, energy, materials, labor) contributes to a change in the value of an industry's output. For example, in 1983 a 1% increase in services purchased by manufacturing would have resulted in a 0.5% change in manufacturing output. These factor shares must all add to 1 if, as is usually assumed, the total output of manufacturing businesses would increase by 1% if all purchased inputs increased by 1%.

SOURCES: William Gullickson and Michael J. Harper, "Cost Function Models and Accounting for Growth in U.S. Manufacturing: 1949-1983," paper prepared for the American Economic Association, New Orleans, LA, Dec. 28-30, 1986; U.S. Department of Labor, Bureau of Labor Statistics, unpublished.

falling prior to the oil embargo, has since risen significantly. Capital productivity has fallen sharply, as has the measured productivity of purchased services. The "multi-factor" productivity measure represents the combined effect of productivity changes in all the inputs (the "single factor" productivities weighted by the "factor shares" outlined below and in the second part of the table).

The changes in rates of productivity improvement were clearly tied to differences in the relative costs of the different inputs. The price of labor grew much faster than any other factor between 1949 and 1973, while labor prices grew more slowly than energy or material prices from 1973 to 1983. During the earlier period, labor price increases were responsible for two-thirds of the increase in manufacturing input prices, while they were responsible for only 45 percent during the later period.

The relative importance of inputs combined in the manufacturing industries is shown in the second part of table 6-10. It indicates, for example, that purchased services made twice the contribution to manufacturing in 1983 than they did in 1949. In 1949, a 10 percent increase in the amount of services purchased by manufacturers would have resulted in a 0.5 percent increase in manufacturing output. In 1983, it would have increased manufacturing output by 1 percent. The role of energy also increased, while capital inputs become comparatively less important.

The productivity changes of each source are combined to show how they have contributed to labor productivity. The result, displayed in table 6-11, indicates that the output per hour worked in manufacturing in the 1973-83 period was considerably below that of the 1949-73 period. What is striking is the sharp decline in the growth rate clearly attributable to technical change (the "multi-factor" productivity) in the recent period, which has occurred despite a significant increase in capital invested per worker. During the 1973-83 period, increased purchases of services per manufacturing worker and increased purchases of materials per worker were, taken together, four times as important as increases in measured multi-factor productivity.

Table 6-11.—Contributions to Changes in Output per Hour Worked

Contributing factor	1949-73	1973-83
Output/Hour (O/H)	2.57	1.51
O/H attributable to growth in Multi-Factor Productivity	1.34	0.15
O/H attributable to growth in inputs per hour worked	1.22	1.36
Capital/Labor	0.47	0.70
Energy/Labor	0.07	0.01
Materials/Labor	0.41	0.32
Services/Labor	0.27	0.33

SOURCE: M.J. Harper and W. Gullickson, "Cost Function Models and Accounting for Growth in U.S. Manufacturing: 1949-1983," paper prepared for the American Economic Association, New Orleans, LA, Dec. 28-30, 1986.

Part III

The International Connection

The benefits and problems of trade are now felt in virtually every production network. Even sectors that now appear to be insulated from trade, such as residential construction, are likely to find themselves closely tied to international production systems by the turn of the century.

In principle, trade can improve the living standards of Americans and their trading partners. A nation that is able to profit from ingenuity, invention, and inspiration in other countries is more likely to prosper and improve the productivity of its own enterprises than one limited to discoveries and research within its own borders. Even when the poorest nation trades with the richest, trade should improve living standards in both nations by making least-cost products available to both. Trade permits U.S. employment to grow in areas where the United States is relatively productive and has a competitive advantage, and it provides U.S. consumers with access to products at the lowest possible price. Political impediments to trade can retard the development of efficient international production networks by lowering productivity worldwide, and can frustrate development in less affluent nations—robbing U.S. producers of potential sales and possibly creating political instability.

In practice, of course, the benefits of trade are unevenly distributed. Trade creates income for certain businesses, occupations, and regions while reducing income for others. Trade can disrupt lives and communities on a massive scale. The costs of continual readjustment are difficult to measure, but can be high. Improperly managed, trade can undermine the technical leadership of U.S. firms in key areas and even threaten U.S. security interests. The challenge of public policy is to find a way to exploit the clear opportunities of trade while ensuring that the costs and benefits are equitably managed.

The Organization of Part III

Chapter 7 extends the analysis of Part II to include international components of production networks. This discussion shows how trade reshapes domestic production recipes, the scale and scope of domestic business operations, and the geography of production. Building on methods described in chapter 4, it provides a set of tools for understanding how exports generate employment throughout the economy, and how imports are integrated into production networks as substitutes for domestic value-added. The methods can be used to show, for example, how imports of manufactured products lead not only to direct declines in the value-added of manufacturing businesses, but indirectly to declining business for firms tied to manufacturing in production networks.

Chapter 8 examines national trends in trade volume and composition during the past several decades, looking closely at changes in the comparative advantage of U.S. producers. It indicates areas where the United States is gaining advantage (an odd assortment, including a variety of services and products involving heavy use of raw materials) and areas where the United States appears to be losing advantage (many involve products with high technology content). It expands on this analysis to show how trade affects different occupations. Craftsmen, machine operators, and laborers are particularly affected because so much trade involves manufactured products. The chapter also shows, for example, that the United States appears to have become a large net importer of scientific and engineering talent.

The chapter concludes by constructing three views of the future of U.S. trade: one built on the presumption that U.S. comparative advantage will continue to move away from sophisticated manufacturing and toward products with value dependent on natural resources; one built on the assumption that the United States can regain its dominance of world trade in manufactured products of all kinds; and one built on the assumption that technology may lead to a decline in the significance of trade in products generally, due to declining economies of scale in production worldwide and to decreased reliance on scarce materials.

Chapter 9 focuses on the impact of trade on specific sectors of the U.S. economy. Among other topics, it explores shrinking surpluses in U.S. agricultural trade, huge fluctuations in world petroleum markets, and declining U.S. exports in services and "high-technology" products.

Chapter 7

How Trade Enters U.S. Production Recipes

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Chapter 7

How Trade Enters U.S. Production Recipes

TRADE AND U.S. BUSINESS STRUCTURE

Trade affects U.S. business structure in all of the dimensions of change examined in Part II. Trade alters the share that different domestic industries contribute to America's gross national product (GNP), the scale and scope of enterprises, and the geography of production.

Trade alters America's production and consumption recipes in many ways:

- The forces driving structural change in the domestic economy are magnified by the effects of international trade. Increased consumer demand for specialized products has opened up more opportunities for market niche penetration by foreign producers. Niches such as efficient automobiles or video-tape recorders have often proved to be a crucial entry point into U.S. markets.
- The growing complexity of production networks has allowed more points of entry for foreign firms in domestic networks. The complex business networks described in Part II have grown rapidly across international borders. Forces that decrease economies of scale have made domestic producers vulnerable in areas where foreign firms have been able to make better use of new production technology.
- The declining significance of natural resources in emerging production recipes has meant that foreign producers without access to inexpensive energy and materials can compete in U.S. markets—often for the first time. U.S. advantages stemming from vast fertile agricultural lands or inexpensive mineral and energy resources have all but vanished. It is possible that the comparatively high transactional costs associated with U.S. production may place U.S. products at a comparative disadvantage.
- Technology has reduced demands for natural resources, decreased the scale of efficient plants, and led to products where the ratio of value to weight is so high that transportation costs—even overseas transportation costs—can be a comparatively small fraction of total costs.[1] Knowledge and information, perhaps the most important ingredients of successful competition, flow rapidly across borders. Most of the flow cannot even be measured. Efficient, reliable, and comparatively inexpensive communications systems make it easier to coordinate production networks that reach around the globe. All of this makes it easier to form production networks that span large regions.
- Perhaps most importantly, keen international competition has made a capacity for making and marketing products from new technologies critical to survival. Success often hinges on an ability to react quickly, to provide consistent quality, or to tailor products to highly specific applications.

Recipe and Linkages

The increased complexity of linkages connecting different parts of the economy has contradictory effects on trade. On the one hand, the separation of once unified production facilities into networks of component and service enterprises permits more points of entry for both domestic and foreign producers. Telephone equipment installed and maintained in Chicago may have been designed in Palo Alto, California, using parts produced in Japan and Korea. On the other hand, an increased need for coordination between production, sales, and servicing operations, and the increased integration of services and production, can make international coordination cumbersome.

At a minimum, success in international markets now depends on skillful management of both production and service functions. The Japanese, for example, succeeded in penetrating U.S. automobile markets in part because of their heavy investment in U.S. sales and servicing facilities, their skillful use of advertising, and their patience and perseverance in learning about U.S. markets. Sales of advanced PBX (private branch exchange) telephone systems abroad will clearly require a good infrastructure for sales and maintenance. Mastery of banking, insurance, advertising, and other service industries abroad will be of increasing importance for both service exports and exports of manufactured products.[2]

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[1] Sam Cole, "The Global Impact of Information Technology," *World Development*, vol. 14, No. 10/11, 1986.

Changes in Scale and Scope

Trade has an uncertain effect on the scale and scope of businesses operating in the U.S. economy. Anecdotes suggest that trade can present problems in both large, highly concentrated production sectors and sectors characterized by small, entrepreneurial firms.

Competitive problems faced in highly concentrated sectors, like textile machinery, steel, and automobiles, apparently resulted in part from inadequate flexibility in the face of unanticipated competition.[3] Concentrating on price reductions and efficiency achievable from mass economies of scale, such producers failed to see the dangers of having aggressive foreign companies invest heavily in new production techniques and search out market niches world-wide. In time, these niches have grown to encompass large sections of the industry. Foreign firms have all but eliminated U.S. producers of advanced textile equipment, and the U.S. steel and auto industries survive in part because of U.S. trade protection policies. Small U.S. farms have difficulty competing with foreign producers in products other than bulk commodities marketed by major trading companies (in part because foreign governments give major assistance to domestic producers wishing to market a wide variety of products abroad).[4]

On the other end of the production spectrum, such highly entrepreneurial enterprises as the U.S. merchant semiconductor industry—which lives off venture capital in California's "Silicon Valley"—and the U.S. machine tool industry have also faced major competitive problems. They proved vulnerable to the patience and planning of large, integrated Japanese firms which demonstrated a superior ability to transfer learning and resources from one part of their business to another, and to build loyal teams of highly skilled employees. In some cases, U.S. industries have also been vulnerable to foreign practices of limiting access to markets, selling products at "below cost" prices (dumping), and receiving government subsidies.[5]

Geography

In a sense, trade is an extreme reflection of the geographic mobility of production described in the last part of chapter 5. The forces behind shifts in the international location of production are much the same as those that led to greater mobility within the United States. What has changed is that the economic, political, and psychological barriers that once kept most U.S. firms isolated from the international marketplace have all but vanished. The change appears to be irreversible. Once a firm has demonstrated that a manufacturing enterprise can operate successfully from South Korea, making use of indigenous labor skills, local port facilities and other physical infrastructure, and enjoying government support for its profitable operation, it is easier for the next firm to enter. Once Taiwan established itself as a reliable producer of high-quality, low-cost components in one field, it could build on that reputation and encourage multinational firms to consider the country as a site for other production facilities. The removal of investment uncertainty is thus an important and usually irreversible process, barring a major domestic upheaval.

Trade has clearly helped reshape the landscape of production. As in the case of domestic geographic movement, however, the theoretical possibility of locating production facilities more evenly around the world has not necessarily resulted in even rates of post-war economic development. Conflicting forces are at work. Much of the world seems unable to join what is called the "convergence club"—a group of nations whose economies have become much more similar during the past century.[6] Members of this "club" seem to be able to learn from each other. While relative positions may change, all have enjoyed real growth while the gap separating these nations from the rest of the world has not narrowed.

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[2] U.S. Congress, Office of Technology Assessment, *International Competition in Services*, OTA-ITE-328 (Washington, DC: U.S. Government Printing Office, July 1987).

[3] See the thesis of Michael Piore and Charles Sable, *The Second Industrial Divide* (New York, NY: Basic Books, 1984).

[4] U.S. Congress, Office of Technology Assessment, *A Review of U.S. Competitiveness in Agricultural Trade—A Technical Memorandum*, OTA-TM-TET-29 (Washington, DC: U.S. Government Printing Office, October 1986).

[5] For an example, see Andrew S. Grove, "Regain Leadership by Working Together," *The New York Times*, Dec. 13, 1987.

Technology makes it comparatively easy for businesses to base decisions on factors such as the availability of an educated and trainable work force, the availability of beneficial tax policies, and other factors that might influence business climate. Indeed, there is reason to believe that the striking success enjoyed by the Pacific Rim nations during the last decade depended heavily on their ability to provide workers with comparatively good high school training at comparatively low wages.[7]

Interestingly, the fast-moving production networks emerging in the world economy may work to increase the advantage of being close to markets, because successful participation in tightly integrated networks depends heavily on a firm's ability to respond quickly with new products and production systems.[8] Many of the new service professions are necessarily disaggregated, since they depend entirely on proximity to clients. The maintenance of complex telephone systems, the installation of software, and the provision of health services all demand close association with clients. Improved transportation networks and inventory control systems permit retailers to offer a wider range of products; at the same time, retailers attempting to keep a large range of products in stock without large inventories need suppliers located where they can deliver quickly and reliably. Auto assembly relying on "just in time" inventories similarly benefits from close proximity. Chapter 6 gave several other examples of technology capable of identifying and reaching niche markets throughout the Nation.

There are other strong links with location, however, that are more difficult to measure in standard statistical terms. In spite of the theoretical advantages of communication in displacing travel, there appears to be no good substitute for real physical proximity in many advanced transactional services. The expanded legal, accounting, financial, insurance, and other services gaining a large fraction of national employment appear to require the undisputed benefits of casual meetings, the reading of a face, or a handshake. These are businesses where perceptions are often as important as anything measurable. The result of this has been significant concentration of many advanced services in a few centers, such as New York, Tokyo, London, and Los Angeles.

There has been a marked change in the geography of U.S. trade. A number of Asian nations have become major markets for U.S. exports and major suppliers of U.S. imports. In 1975, Asia accounted for one-quarter of both U.S. imports and exports. By 1984 the Asian share of U.S. exports had risen to 30 percent while 37 percent of all U.S. imports came from Asia, making it the largest supplier of goods to the U.S. market. Trade with Asia now accounts for more than 50 percent of the total U.S. merchandise trade deficit. The countries involved are mainly Japan, Taiwan, South Korea, Hong Kong, and Singapore.

Table 7-1 shows how rapid change has been during the past decade. In 1975, 50 percent of the net trade surplus with non-OPEC countries was used to finance oil imports, resulting in an enormous trade deficit with the oil producers. By 1986, imports from OPEC nations accounted for only 6 percent of the U.S. trade deficit. OPEC's share of U.S. exports fell from 9 percent in 1975 to 5 percent in 1986. However, the collapse of U.S. exports occurred because nations that formerly purchased U.S. exports reduced their purchases in real terms.

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[6] William J. Baumol, "Productivity Growth, Convergence and Welfare: What the Long Run Data Show," C.V. Starr Center for Applied Economics, RR#85-27, August 1985.

[7] Harold M. Stevenson, "Mathematics Achievement of Chinese, Japanese, and American Children," *Science*, vol. 231, No. 4739, Feb. 14, 1986, p. 693.

[8] For further elaboration of this point see Peter Drucker, "The Changed World Economy," *Foreign Affairs*, vol. 64, No. 4, pp. 768-791, spring 1986; and James Brian Quinn, "The Impact of Technology in the Services Sector," Bruce R. Guile and Harvey Brooks (eds.), *Technology and Global Industry* (Washington, DC: National Academy Press, 1987), pp. 119-159.

Table 7-1.—The Geography of U.S. Merchandise Trade (billions of dollars)

	1975			1986		
Location	Exports (from U.S.)	Imports (to U.S.)	Balance	Exports (from U.S.)	Imports (to U.S.)	Balance
Total	107.1	98.2	8.9	221.8	369.5	−147.7
Western Europe	29.9	20.8	9.1	60.7	89.3	−28.6
European Community	22.9	16.5	6.3	52.2	74.5	−22.3
Others	7.0	4.3	2.8	8.5	14.8	−6.3
Canada	23.5	21.9	1.7	54.2	70.3	−16.0
Japan	9.6	11.3	−1.7	26.4	81.0	−54.6
Australia, New Zealand, South Africa	3.5	2.2	1.3	7.1	6.0	1.2
Eastern Europe	3.2	0.7	2.5	2.0	2.0	0.0
Latin America	17.1	16.2	0.9	30.9	41.5	−10.6
Asia & Africa	20.2	25.2	−4.9	40.4	79.4	−39.0
Hong Kong, Singapore, South Korea, Taiwan	N.A.	N.A.	N.A.	17.3	46.1	−28.8
OPEC[a]	7.3	14.7	−7.4	6.8	12.7	−5.9
Other	12.9	10.4	2.5	16.3	20.6	−4.3

[a] Organization of Petroleum Exporting Countries. Total shown does not include Venezuela, Ecuador.

N.A. = not available.

SOURCE: U.S. Department of Commerce, *Survey of Current Business*, vol. 66, No. 6, June 1986, pp. 48-50; vol. 67, No. 3, March 1987, pp. 45-46.

FOLLOWING TRADE THROUGH DOMESTIC PRODUCTION NETWORKS

Between 1972 and 1984, trade's effect on the GNP share of several production sectors was as large as the effect of domestic demand. One of the difficulties in evaluating the effect of trade on the U.S. economy, however, is that the beneficiaries of trade are difficult to identify, while those adversely affected by imports are vigorous in making their presence known. A plant closed because imported clothing has underpriced the domestic product is a tragedy because the pain is concentrated on relatively few individuals. Consumers as a whole, however, may benefit from less expensive clothing due to these imports. Taken collectively, the advantages derived from trade may outweigh the costs, though the costs and benefits are not distributed equally.

Unfortunately, national statistics are virtually useless in making a detailed calculation of the ways trade affects U.S. production networks to the benefit of U.S. consumers. There is no way, for example, to look at the National Income and Product Accounts or the input-output accounts to determine whether the steel purchased by an automobile company is imported or produced by a domestic firm.

Even given this information, it is not easy to determine how the U.S. economy would operate in the absence of trade. Many products and services simply cannot be produced domestically at any price, such as a trip to Paris. There are other areas where expanding domestic production to replace imports would be prohibitively expensive—displacing imports, for example, would require doubling domestic petroleum production. Moreover, products are imported with prices and characteristics that cannot easily be matched by domestic production; if imports were not available, the prices of many products in the U.S. economy would be radically changed. Consumption and production recipes would be altered as a result. It is extraordinary difficult to anticipate these shifts given available information. At this writing, consistent deflator series are not available for all imports.

International trade statistics are becoming less reliable as an indicator of real movement of value. For example, measuring the value of technology moving across international borders has always been difficult, but its significance has grown as its value has increased. The value of technology that flows freely in the form of open technical literature, scientific meetings, educational training, and products undoubtedly dwarfs the recorded flow of patents, licenses, and the like. Barter-like trade, not easily included in official estimates, may amount to 30 percent of world trade.[9] Official estimates of U.S. service exports and imports may be 50 to 70 percent too low.[10] In addition, the value of drugs illegally imported to the United States in 1985 could, if measured, increase the U.S. trade deficit by 10 to 50 percent.

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[9] Stephen Cohen and John Zysman, "Countertrade, Offsets, Barter, and Buybacks," *California Management Review*, vol. 28, No. 2, winter 1986, pp. 41-56.

Because of these limitations, the discussion that follows can provide only a very dim light on the way trade has insinuated itself into U.S. production networks. Even this dim light can be useful.

Direct Effects

It is useful to begin by examing the direct effects of trade, following the vocabulary of chapter 4. Leaving doubts about the data aside, table 7-2 shows that nearly one-quarter of merchandise trade appears in categories not closely linked to U.S. producing sectors. Of the remaining trade in goods and services, the most dramatic changes are found in manufacturing. Medium Wage Manufacturing shows an increased share of both imports and exports, primarily because of growing trade in electronics, while High Wage enterprises fall as a share of both imports and exports in spite of the surge in imports of steel, automobiles, and other products of High Wage Manufacturing. In contrast, Transactional Activities have gained in their share of imports, and their share of exports rose to 7.6 percent in 1984—more than a 50 percent increase from 1972.

Indirect Effects

Making the assumption that products made for export are produced in the same way as products made for domestic sales, the methods discussed in chapter 4 can also be used to estimate the domestic business generated by foreign purchases of products and services. Table 7-3 indicates that in 1984, exports generated $38 to $49 billion of value-added in each of the following sectors: Natural Resources, High Wage Manufacturing, Medium Wage Manufacturing, Transportation & Trade, and Transactional Activities. In percentage terms, exports gave the greatest boost to High and Medium Wage Manufacturing and Natural Resources; value-added was between 14 and 19 percent in all three sectors, demonstrating the extent to which U.S. enterprises are involved in

Table 7-2.—Composition of Trade in 1972 and 1984 (in 1980 dollars)

	Percent of all trade in "producing industries"[a]			
	Imports		Exports	
Production sector	1972	1984[b]	1972	1984[b]
Natural Resources	22.3%	20.5%	12.8%	14.9%
Construction	0.0	0.0	0.0	0.0
Low Wage Manufacturing	14.3	16.4	5.3	4.6
Medium Wage Manufacturing	19.3	27.1	21.4	27.7
High Wage Manufacturing	46.1	39.7	39.9	31.2
Transportation & Trade[c]	−2.2	−4.1	14.7	13.4
Transactional Activities	0.2	0.4	5.0	7.6
Personal Services	0.0	0.0	0.6	0.4
Social Services	0.0	0.0	0.3	0.2
Total	100.0	100.0	100.0	100.0
In billions of 1980 dollars:				
Value of trade in "producing industries"[a]	$138.8	$306.5	$117.7	$231.0
Value of trade in "special industries"[a]	59.4	106.1	40.3	83.1
Total	198.2	412.6	157.9	314.1

[a] "Producing" industries differ from "special industries" in that the latter are not linked to the rest of the economy generating no intermediate inputs and, with minor exceptions, no domestic jobs. The "special industries" that contribute to trade include scrap, "non-comparable" imports, and "rest of the world" industry. An import is "noncomparable" if (1) there is no significant domestic production (e.g., bananas); (2) the item is purchased and used outside the United States (e.g., foreign travel); or (3) it is one of several miscellaneous items that are not easily assigned to a U.S. production category (e.g., antiques or fossils). The "rest of the world" trade includes income on foreign investments, compensation of U.S. residents working abroad, and private payments on foreign assets.

[b] Bureau of Labor Statistics estimates rebased into 1980 dollars.

[c] Includes duties on imported products.

NOTE: Totals may not equal 100 due to rounding.

SOURCE: Office of Technology Assessment, based on U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, "Dollar Value Tables for the 1972 Input-Output Study," April 1979; U.S. Department of Labor, Bureau of Labor Statistics, 1984 trade estimates, unpublished.

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[10] U.S. Congress, Office of Technology Assessment, *Trade In Services: Exports and Foreign Revenues—Special Report*, OTA-ITE-316 (Washington, DC: U.S. Government Printing Office, September 1986).

Table 7-3.—Domestic Value-Added Generated by Exports in 1984

Production sector	Billions of 1980 dollars	Percent of value-added in sector
Natural Resources	$39.2	14.6%
Construction	8.0	4.4
Low Wage Manufacturing	9.2	9.6
Medium Wage Manufacturing	46.6	16.0
High Wage Manufacturing	48.5	18.5
Transportation & Trade	45.4	8.0
Transactional Activities	38.5	5.6
Personal Services	3.6	3.3
Social Services	2.7	0.6
Total	241.8	8.2

NOTE: The value-added includes all transactions associated directly and indirectly with trade, including domestic production of capital equipment needed to produce exports.

SOURCE: Office of Technology Assessment, based on 1984 U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Products Accounts," historical diskettes with adjustments made to the 1980 Commerce Department Input/Output tables for capital flows and the U.S. Department of Labor, Bureau of Labor Statistics, "Employment Requirements," unpublished, and 1984 trade estimates rebased into 1980 dollars, unpublished.

world trade. Measured in terms of absolute value generated by exports, $104 billion ends up as value-added in manufacturing sectors (44 percent of the total) while nearly $84 billion appears as value-added in Transportation & Trade and Transactional Activities.

The effects of imports are much more difficult to estimate for reasons already discussed. It is possible to obtain a rough estimate about the effects of imports, presented in table 7-4, by making three admittedly heroic assumptions:

1. domestically produced commodities can be used as direct replacements for all "comparable" imports, and can be produced at the same price as imported products (import price plus tariffs);
2. the ratio of imported commodities to domestically produced commodities consumed is the same for households, government, and businesses purchasing ("intermediate demand"); and
3. the ratio of imported commodities to domestically produced commodities consumed is the same for all businesses (e.g., if imports represent 10 percent of all steel consumed in the United States, the automobile industry imports 10 percent of the steel it consumes).

Once changes in the output of industries resulting from the direct and indirect effects of trade have been calculated, the impact of trade on jobs can be computed with the assumption that employment in

Table 7-4.—Domestic Value-Added Theoretically Offset by Imports in 1984

Production sector	Billions of 1980 dollars	Percent of value-added in sector
Natural Resources	$95.5	35.5%
Construction	15.2	8.4
Low Wage Manufacturing	34.3	35.9
Medium Wage Manufacturing	70.6	24.3
High Wage Manufacturing	81.4	31.0
Transportation & Trade	34.6	6.1
Transactional Activities	34.1	5.0
Personal Services	3.7	3.5
Social services	3.4	0.7
Total	373.0	12.7

NOTE: The value-added includes all transactions associated directly and indirectly with trade, including domestic production of capital equipment needed to produce exports. Duties collected on imported products have been excluded from the calculations.

SOURCE: Office of Technology Assessment, based on 1984 U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Products Accounts," historical diskettes with adjustments made to the 1980 Commerce Department Input/Output tables for capital flows and the U.S. Department of Labor, Bureau of Labor Statistics, "Employment Requirements," unpublished, and 1984 trade estimates rebased into 1980 dollars, unpublished.

an industry changes in proportion to industry output (see table 7-5). Given the large trade imbalance of 1984, the methods just described indicate that imports resulted in a loss of over 9 million jobs, while exports only generated 6.5 million jobs.

As could be expected, jobs in manufacturing were most heavily affected by both imports and exports. In percentage terms, the Medium and High Wage Manufacturing sectors taken together were the most affected by imports but also benefited the most from exports. While nearly 13 percent of employment in the Transactional Activities sector is attributable to exports (directly from this sector and indirectly from others), the Personal and Social Services sectors were not as heavily affected by either imports or exports.

Methods similar to those used to estimate net effects on employment in different businesses can be used to show how trade influences demand for people with different skills (see tables 7-6 and 7-7). Trade has clearly benefited some groups at the expense of others. As expected, export jobs are heavily dominated by manufacturing professions and agriculture. A large fraction of all technical professionals (14 percent of all engineers, 12 percent of all engineering technicians, and 8 percent of all scientists) owe their jobs to exports. Social service occupations (teaching, health, and other areas) are among those affected least.

While the calculations about the employment effects of imports lack precision, they do suggest that trade has deeply penetrated most U.S. production networks that involve manufactured products, including those that rely heavily on engineering and scientific personnel. Indeed, technical professions are among the most heavily affected by both imports and exports, as are skilled and unskilled employees in manufacturing.

It is possible, of course, that the statistics overstate the loss of domestic scientific and engineering research. Many foreign designs incorporate U.S. engineering. U.S. research may well continue in spite of the loss of some domestic production, although it seems unlikely that U.S. firms can continue to maintain vigorous research programs without an ability to recapture the investment through production. On the other hand, the statistics presented later in this chapter will show that the United States is importing a great deal of engineering talent. The Japanese appear to expend much more engineering talent in some areas of production than U.S. firms.

Taken as a whole, the United States appears to export products requiring relatively large amounts

Table 7-5.—The Impact of 1984 Trade on Domestic Employment by Industry Group

Production sector	Percent of jobs in sector: Lost to imports	Percent of jobs in sector: Gained from exports	Jobs in sector as percent of all U.S. jobs in 1984
Natural Resources	8.2%	8.1%	3.5%
Construction	3.9	2.9	4.5
Low Wage Manufacturing	16.9	5.6	4.6
Medium Wage Manufacturing	25.9	23.7	9.6
High Wage Manufacturing	18.6	15.8	5.9
Transportation & Trade	15.2	27.6	26.3
Transactional Activities	8.7	12.9	13.0
Personal Services	1.5	2.1	5.5
Social Services	1.0	1.3	27.2
Total	100.0	100.0	100.0
Millions of jobs	**9.3**	**6.5**	**96.9**

How To Read This Table: In 1984, 3.5% of the 96.9 million wage and salary jobs in the U.S. were in Natural Resource industries. Exports of Natural Resource products accounted for 8.1% of the 6.5 million jobs generated by all U.S. exports. Of the 9.3 million jobs hypothetically displaced by imports, 8.2% were in Natural Resource industries.

NOTES:
- Totals may not equal 100 due to rounding.
- Includes both direct and indirect trade effects and the effects on capital purchases.
- Uses 1980 input/output and 1984 occupation by industry matrix.
- Duties collected on imported products have been excluded from the calculations.
- Job totals represent only wage and salary earners in 1984 (self-employed not included).

SOURCE: Office of Technology Assessment, based on U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, Input-Output Tables: 1980, unpublished; U.S. Department of Labor, Bureau of Labor Statistics, "Employment Requirements," unpublished, and 1984 trade estimates rebased into 1980 dollars, unpublished.

Table 7-6.—Jobs (Wage and Salary) Lost Directly and Indirectly to Imports of Comparable Products in 1984
(ranked with the occupations losing most employment at the top)

Occupation category	Jobs lost as percent of all jobs in the occupation in 1984	Jobs lost as percent of all jobs lost to imports in 1984
Extractive and related workers	53.9	1.0
Hand working occupations	31.9	8.7
Machine setters, set-up operators, operators	27.0	15.8
Precision production occupations	22.7	6.4
Blue collar worker supervisors	21.8	3.1
Engineers	21.1	3.0
Engineering and science technicians	17.2	2.4
Helpers, laborers, and material movers	14.5	6.4
Plant and system occupations	13.5	0.4
Natural, computer, and mathematical scientists	12.0	0.8
Material records, scheduling, dispatching	11.9	3.1
Mechanics, installers, and repairers	11.0	4.7
Transportation and material moving operators	10.6	4.9
Technicians, except health and engineering	10.6	0.6
Computer operators and peripheral equipment	10.0	0.3
Management support occupations	9.8	2.3
Construction trades	9.8	2.7
Average of all occupations	9.6	100.0
Agriculture, forestry, fishing	9.2	1.8
Architects and surveyors	8.5	0.1
Managerial and administrative occupations	8.4	7.1
Financial records processing occupations	8.3	2.1
Duplicating, mail, and other office machines	7.7	0.1
Records processing occupations, except finance	7.4	0.7
Secretaries, stenographers, and typists	7.2	3.0
Mail and message distribution workers	7.2	0.6
Writers, artists, entertainers, and athletes	7.0	0.6
Marketing and sales occupations	6.4	6.4
Communications equipment operators	6.3	0.3
Other clerical and administrative support	6.2	3.8
Lawyers and judges	6.1	0.2
Cleaning and building service occupations	5.3	1.6
All other professional, paraprofessional, and technical	5.3	0.4
Information clerks	5.1	0.4
All other service occupations	4.7	0.4
Adjusters and investigators	3.9	0.2
Protective service occupations	3.3	0.7
Food and beverage preparers	2.8	2.0
Personal service occupations	2.6	0.2
Social scientists	2.3	0.0
Health technicians and technologists	1.0	0.1
Health diagnosing and treating occupations	0.8	0.2
Health service and related occupations	0.4	0.1
Social, recreational, and religious workers	0.3	0.0
Teachers, librarians, and counselors	0.2	0.1
Private household workers	0.0	0.0

How To Read This Table: Of the 9.3 million jobs replaced by trade in 1984, 8.7% were in "hand working occupations." Imports substituted for 31.9% of all 1984 hand working jobs.

NOTE: Duties collected on imported products have been excluded from the calculations.

SOURCE: Office of Technology Assessment, based on U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, Input-Output Tables: 1980, unpublished; U.S. Department of Labor, Bureau of Labor Statistics, "Employment Requirements," unpublished, and 1984 trade estimates rebased into 1980 dollars, unpublished.

Table 7-7.—Jobs (Wage and Salary) Gained Directly and Indirectly by Exports in 1984
(ranked with the occupations gaining most employment at the top)

Occupation category	Jobs gained as percent of all jobs in the occupation in 1984	Jobs gained as percent of all jobs gained from exports in 1984
Hand working occupations	16.7	6.5
Agriculture, forestry, fishing	15.8	4.3
Engineers	14.3	2.9
Extractive and related workers	13.0	0.3
Precision production occupations	12.4	5.0
Blue collar worker supervisors	12.1	2.5
Engineering and science technicians and technologists	11.8	2.3
Machine setters, set-up operators, operators	11.5	9.6
Material records, scheduling, dispatching	9.2	3.4
Transportation and material moving operators	9.1	6.0
Plant and system occupations	8.7	0.4
Architects and surveyors	8.6	0.1
Technicians, except health and engineering	8.3	0.7
Mechanics, installers, and repairers	8.1	4.9
Natural, computer, and mathematical scientists	7.9	0.8
Computer operators and peripheral equipment	7.7	0.4
Management support occupations	7.3	2.5
Marketing and sales occupations	7.1	10.1
Writers, artists, entertainers, and athletes	6.8	0.8
Duplicating, mail, and other office machines	6.7	0.2
Average of all occupations	6.7	100.0
Financial records processing occupations	6.5	2.4
Managerial and administrative occupations	6.5	7.8
Communications equipment operators	6.3	0.5
Mail and message distribution workers	6.3	0.8
Lawyers and judges	6.1	0.3
Records processing occupations, except finance	5.7	0.8
Secretaries, stenographers, and typists	5.6	3.3
Construction trades	5.5	2.1
Other clerical and administrative support	5.1	4.5
Information clerks	5.1	0.5
All other professional, paraprofessional, and technical	4.5	0.5
Cleaning and building service occupations	4.4	1.9
All other service occupations	3.9	0.5
Adjusters and investigators	3.8	0.3
Personal service occupations	3.1	0.4
Protective service occupations	3.1	0.9
Food and beverage preparers and service occupations	2.5	2.5
Social scientists	2.0	0.1
Health diagnosing and treating occupations	0.9	0.3
Health technicians and technologists	0.9	0.2
Health service and related occupations	0.4	0.1
Social, recreational, and religious workers	0.3	0.0
Teachers, librarians, and counselors	0.2	0.1
Private household workers	0.0	0.0

How To Read This Table: Of the jobs gained by exports in 1984, 6.5% were in "hand working occupations." Exports were responsible for 16.7% of all hand working jobs.

SOURCE: Office of Technology Assessment, based on U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, Input-Output Tables: 1980, unpublished; U.S. Department of Labor, Bureau of Labor Statistics, "Employment Requirements," unpublished, and 1984 trade estimates rebased into 1980 dollars, unpublished.

of labor and relatively small capital inputs compared to U.S. imports. This paradoxical result, first identified by Wassily Leontief in 1953,[11] exhibits relative stability over time (see table 7-8).[12]

The higher capital to labor ratio of imports is due in part to the fact that exports include a significant amount of sales and related employment not included in import accounts; sales workers represented 7.1 percent of all jobs gained by exports and 6.4 percent of jobs lost to imports. It is also possible that U.S. exports embody an unusually large amount of associated service employment when they consist of relatively advanced products, while U.S. firms threatened by imports tend to compete with heavy capitalization to offset higher foreign labor costs.[13] On the other hand, it could also mean that foreign firms have successfully penetrated the most capital-intensive and productive parts of U.S. manufacturing.

Another way to explore this issue is to examine the effect of trade on employment using measures other than occupation descriptions. The result is difficult to interpret. In spite of large differences in the kinds of jobs created and lost by trade, the average wages (calculated by weighting average occupation wages by the number of jobs gained or lost in the occupation) of jobs gained and lost are virtually identical (see table 7-9).[14] Individuals losing jobs because of imports are slightly more likely to be males who are not well educated. Not surprisingly, they are much more likely to be in an occupation with high levels of unemployment.

Because of the large trade deficit in 1984, the United States was actually a net importer of almost every class of worker in that year. In 1972, a year in which the value of exports and imports was close to being in balance, the United States was a net exporter of work by the college-educated in spite of considerable displacement of technical personnel. Given balanced trade, the United States would also be a net exporter of female employment.[15]

Linkages

While manufactured products represent the bulk of direct imports (again see table 7-2), imports lead to significant declines in value-added and employment in non-manufacturing sectors as well because of the extensive linkages connecting manufacturing to the rest of the economy. Loss of domestic automobile production translates directly into losses for the firms that provide marketing, financing, and other services to domestic automobile producers.

The linkages connecting the fate of different parts of the economy are shown in particularly vivid terms when imports substitute for domestic production. These links are examined directly in table 7-10, which separates trade into three components: trade in natural resource and construction goods, trade in manufactured products, and trade in services. The table indicates that while 89 percent of all jobs lost to imports in 1984 resulted from imports of manufactured products, only two-thirds of these lost jobs were manufacturing jobs. Imports of manufactured goods resulted indirectly in the loss of over 2 million service jobs, primarily in the Transportation & Trade and Transactional Activities sectors. In other words, for every 15 jobs lost due to imported manufactured products, 10 were jobs lost in manufac-

Table 7-8.—Capital/Labor Ratios of U.S. Exports and Imports (capital per unit of labor in 1979 dollars per person year of competitive imports and exports)

Year	Export ratio	Import ratio	Ratio (E/I)
1963	37.5	49.2	0.76
1967	40.7	48.9	0.83
1972	53.0	59.6	0.89
1977	56.0	74.6	0.75

NOTE: Technical matrices apply to the year indicated.

SOURCE: W. Leontief and F. Duchin, "Automation, the Changing Pattern of U.S. Exports and Imports, and their Implications for Employment," National Science Foundation, (PRA 83-11407), March 1985, pp. 2.26-2.27.

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[11] Wassily Leontief, "Domestic Production and Foreign Trade: The American Capital Position Reexamined," Proceedings of the American Philosophical Society, September 1953.

[12] Wassily Leontief and Faye Duchin, "Automation, the Changing Pattern of U.S. Exports and Imports, and Their Implications for Employment," Final Report for the National Science Foundation, March 1985, p. 22.

[13] See U.S. Congress, Office of Technology Assessment, *Technology and Structural Unemployment: Reemploying Displaced Adults*, OTA-ITE-250 (Washington, DC: U.S. Government Printing Office, February 1986).

[14] Weighting wages by *industry*, however, can yield a result where higher paid jobs are being lost to imports as opposed to those generated by exports. See Lester Thurow, "A Surge in Inequality," *Scientific American*, vol. 256, No. 5, May 1987, pp. 237.

[15] See Charles F. Stone and Isabel V. Sawhill, "Labor Market Implication of the Growing Internationalization of the U.S. Economy," contract report for the National Commission for Employment Policy, Washington, DC, February 1986.

Table 7-9.—Characteristics of Jobs in 1984, Using 1972 and 1984 Trade Patterns

Category	1984 trade patterns: Average (all jobs)	1984 trade patterns: Lost to imports	1984 trade patterns: Gained by exports	1972 trade patterns: Average (all jobs)	1972 trade patterns: Lost to imports	1972 trade patterns: Gained by exports
Workers (millions)	96.9	9.3	6.5	98.7	5.0	4.7
Weekly earnings	$330	$329	$328	$330	$329	$330
% unemployed	6.6	7.6	7.1	6.6	7.6	7.2
Demographics:						
% female	46.0	38.4	40.1	45.8	37.8	40.1
% black	13.2	12.5	12.4	13.2	12.5	12.4
Education:						
% no diploma	18.2	22.3	20.5	18.4	22.3	20.5
% high school graduate	61.2	63.2	63.2	61.2	63.3	63.3
% college graduate	20.6	14.5	16.3	20.4	14.4	16.2
Age:						
% age 16-24	20.2	19.6	19.9	20.2	19.7	19.8
% age 25-54	69.0	69.7	69.3	69.0	69.5	69.4
% age 55+	10.8	10.8	10.9	10.8	10.8	10.8

NOTE: Job totals do not include self-employed workers.

SOURCE: Office of Technology Assessment, based on data provided by the U.S. Department of Commerce, Bureau of Economic Analysis, and the U.S. Department of Labor, Bureau of Labor Statistics.

turing industries, 4 were in services, and 1 was in the natural resource sector.

A similar interdependence between sectors is evident in the case of natural resource imports. For every 10 jobs lost due to imports of these goods, 5 were lost in the natural resource and construction sector, 3 service sector jobs were eliminated, and 2 manufacturing jobs were lost.

Service sector imports did not appreciably affect the other two sectors. Although the absolute loss of

Table 7-10.—The Linkage Effect of Trade on U.S. Employment in 1984
(wage and salary jobs created or lost by production sector, in percent)

Production sector	Jobs lost by imports of: NRC	Jobs lost by imports of: Manufact.	Jobs lost by imports of: Services	Jobs gained by exports of: NRC	Jobs gained by exports of: Manufact.	Jobs gained by exports of: Services
Natural Resources and Construction (NRC)	**50.5%**	**6.5%**	**1.8%**	**45.7%**	**6.5%**	**4.0%**
Natural Resources	36.9	4.0	0.7	40.2	4.0	1.5
Construction	13.6	2.5	1.1	5.5	2.5	2.5
Manufacturing	**18.9**	**65.9**	**8.8**	**18.5**	**64.2**	**10.5**
Low Wage Manufacturing	2.7	18.6	1.0	2.6	7.9	1.4
Medium Wage Manufacturing	10.1	27.4	6.2	9.1	33.7	6.0
High Wage Manufacturing	6.1	19.9	1.6	6.8	22.6	3.1
Services	**30.6**	**27.7**	**89.4**	**35.8**	**29.3**	**85.6**
Transportation & Trade	17.1	17.2	6.3	22.3	17.9	55.3
Transactional Activities	10.8	8.0	75.7	11.0	8.7	24.6
Personal Services	1.4	1.5	5.5	1.5	1.7	3.6
Social Services	1.3	1.0	1.9	1.0	1.0	2.0
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0
Total (000s of jobs)	(997.5)	(8,290.0)	(50.2)	848.3	4,082.1	1,611.4

Read the table as follows: Of the 8.29 million jobs lost due to importing manufacturing products in 1984, 27.7 percent were lost in service industries through indirect linkages. Of the 848,300 jobs gained due to natural resource and construction exports, 40.2 percent were gained in the Natural Resource sector itself.

NOTES:
- Brackets denote job loss.
- Totals may not equal 100 due to rounding.

SOURCE: Office of Technology Assessment, based on U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, Input-Output Tables: 1980, unpublished; U.S. Department of Labor, Bureau of Labor Statistics, "Employment Requirements," unpublished, and 1984 trade estimates rebased in 1980 dollars, unpublished.

jobs attributed to service imports was small, over 89 percent of the losses were contained to the service sectors—76 percent in the Transactional Activities sector alone. The largest non-service impact was felt in Medium Wage Manufacturing, presumably because it produces service industry equipment like computers, photocopiers, and typewriters.

While linkages spread the losses resulting from imports, they also spread the wealth resulting from exports. In 1984, the export of manufactured goods was responsible for 62 percent of all jobs created by exports. Services played a much larger role on the export side than was the case with imports, generating 1.6 million jobs—nearly one-quarter of all the jobs created by exports. Nevertheless, of all the service sector jobs created through exports, over a million jobs (41 percent) were attributable to manufacturing exports. Ten percent resulted from natural resource and construction exports. As was the case in imports, the export of service products generates few jobs outside the service sector.

Although these calculations are based on limited data, they can provide a rough idea of the relative impact of trade and how it ripples through the economy. It underscores the interdependence of the U.S. production sectors, revealing that the health of one industry is dependent on the success of the others. This is especially true for trade-related service sector jobs, which are tightly connected to the manufacturing sector.

The calculations, of course, may not show some of the most important aspects of trade linkages.[16] Domestic production may be essential for earning profits needed to maintain the momentum of research. Proximity to production facilities may be needed to manage an effective research and development program. Research and development teams that are widely separated from production systems, or located in firms no longer producing products, appear less likely to keep abreast of the most relevant engineering products and less likely to find inspiration in the practical difficulties of the work place.[17]

Trade and the Amenities

Using the techniques just described, it is also possible to trace the effect of trade through both consumption and production networks to show how the provision of different amenities (as outlined in Part I) is affected by trade. Table 7-11 shows to what degree Americans depend on imported products for different amenities. The U.S. Transportation system benefits heavily from imports, both because of heavy imports of fuel needed to power vehicles and because a large proportion of the vehicles themselves are imported. Heavy dependence on imports can, of course, be a mixed blessing. It is an indication that consumers may be enjoying lower prices or more choice in goods and services as a result of trade, but it can also mean that the amenity based on the imported commodity is vulnerable to manipulation by foreign producers.

Clothing and Personal Care is heavily affected by trade, primarily because of rapidly growing imports of labor-intensive clothing. Imports represented 12 percent of Recreation and Leisure spending even though the accounts shown do not include foreign travel (a "non-comparable" item). Purchases of imported home electronics, foreign recreational vehicles, toys, and other items have obviously improved

Table 7-11.—Imports as a Percent of Domestic Spending by Amenity in 1984[a]

Amenity	Percent
Transportation	21.2
Clothing and Personal Care	18.7
Federal Defense	12.5
Exports	12.2
Recreation and Leisure	11.6
Food	9.6
Housing	8.1
Government (N.E.C.)	7.0
Health	6.3
Personal Business and Communication	6.2
Education	4.9
National average	**10.7**

[a] Does not include noncomparable imports.

N.E.C. = Not elsewhere classified.

NOTE: These estimates include all direct and indirect imports required to meet each class of amenity. They include imports of capital goods needed for domestic producers to satisfy the amenity. They also include transportation, trade, and transaction costs associated with imports, less costs that would have been incurred whether or not the item was imported. This means that only the incremental cost of transportation and handling is associated with an import.

SOURCE: Office of Technology Assessment, based on U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, Input-Output Tables: 1980, unpublished; U.S. Department of Labor, Bureau of Labor Statistics, "Employment Requirements," unpublished, and 1984 trade estimates rebased into 1980 dollars, unpublished.

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[16] Stephen Cohen and John Zysman, *Manufacturing Matters: The Myth of a Post-Industrial Economy* (New York, NY: Basic Books, 1987).

[17] OTA is currently studying this issue in greater depth. See *Technology, Innovation, and U.S. Trade*, forthcoming.

the quality of leisure for many Americans. Virtually all Food imports involve what agricultural traders call "high-value" products—those other than bulk grains. Imports of fruits, vegetables, and foods that reflect foreign tastes (i.e., Italian tomatoes or Dutch beer) have grown so large that they equal U.S. exports of grains.[18]

In Housing, direct imports are largely limited to purchased energy (primarily oil) needed for heating, a large variety of home appliances, and building components. In the future, however, it is possible that imports will grow to include a much wider variety of housing components—possibly entire house sections. These issues are discussed in greater detail in chapter 9.

Table 7-11 also includes the indirect effects of imports, such as the sophisticated machines that produce domestic fabrics (virtually all imported), food processing equipment (heavily imported), machine tools that increase the productivity of domestic automobile manufacturing, and other items in the complex production networks serving U.S. consumers.

Under the assumptions made here, even 12.5 percent of Federal Defense spending results directly or indirectly from imported items. This may overstate vulnerability since DoD tries to select "domestic" products but many "domestic" products have foreign components. A recent Defense Science Board analysis found that defense purchases are often faced with a choice between buying the best item and buying a domestically produced item.[19]

The growth of production networks across international borders is apparent from the fact that fully 12 percent of the value of U.S. exports results from imported products. If nothing else, the competitive position of U.S. exported products is heavily dependent on the price and availability of imported products. Connections become apparent during events such as the recent attempt to block Japanese semiconductor imports through high tariffs. One immediate result was concern about an increase in the cost of U.S. products containing imported semiconductors.

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[18] *A Review of U.S. Competitiveness in Agricultural Trade—A Technical Memorandum*, op. cit., footnote 4.

[19] Defense Science Board, "Task Force on Defense Semiconductor Dependency," Washington, DC, December 1986.

A FINAL ASSESSMENT: WEIGHING THE COSTS AND BENEFITS OF TRADE

Given the complex way that trade has insinuated itself into the Nation's production networks, its net effect is obviously difficult to measure with precision. While the advantages of trade can be clearly demonstrated in a world where prices and products are comparatively predictable, it is possible that trade can lead to real hardship during periods of rapid change. Comparative advantage in today's international markets depends heavily on a producer's ability to capture the "rents" of innovation when marketing products that embody new technology, in order to recover investment in research and development.

It is entirely possible that if foreign firms prove more adroit in exploiting technical opportunities, and if this results in a situation where industries with the potential for rapid productivity growth fail in the United States, the United States could find itself specializing in comparatively poorly paid industries while importing technically sophisticated products from abroad. The *comparative* position of the U.S. economy could fall if the United States fails to manage trade effectively in a dynamic environment. It is even possible that the *absolute* level of U.S. living standards could decline if trade, in effect, reversed the comparative positions of the United States and trading partners that were formerly less affluent.

Rapid loss of markets in a fast-moving area like consumer electronics can rob a firm of profits needed for research and new investment. Even worse, it can break critical links in the chain connecting production and engineering innovation. American companies that maintained comparative advantage in highly productive manufacturing sectors may be forced out of the market altogether.

The converse of this argument is the difficulty of building comparative advantage in a new area when the pressure of trade makes it difficult for investors to take a chance on an "infant" enterprise. This has been a point of contention in U.S. policy since Alexander Hamilton made the case in his *Report on the Subject of Manufactures*.

It certainly appears that Japan and other nations have been able to make skillful use of trade protection in an overt policy designed to create areas where they will have comparative advantage. The question at issue is whether they could have done better using other means to stimulate development. A critical problem is determining when an enterprise no longer requires protection from trade, since politics invariably plays a large role in creating the answer.

The issue would be largely irrelevant if the United States had succeeded in maintaining a position of leadership in the product cycle. It gains importance when the United States must regain lost markets. The problem becomes all the more vexing in an environment where virtually every enterprise has become an infant in terms of continual rebuilding through innovation. The discussion of Part II suggests that successful enterprises in the emerging economy will, in essence, be perpetual "infants" in the sense that their products and production are in the process of almost continuous change. Even a mature business sector like apparel may be about to embark on a bold venture into new technology. Their case for protection from international competition and trade may be at least as valid as the case made by producers of advanced electronics.

Currency issues present a separate problem. In principle, market forces can lead to adjustments in world wage rates and currency exchange rates over the long term; however, many factors prevent these adjustments from being made rapidly. A nation with rapidly rising productivity, for example, is likely to have a work force whose wages have not risen as rapidly as productivity either because workers fail to capture the higher wages that they might eventually be able to command as a result of productivity growth, or because domestic policies block wage increases as a conscious element of growth policy. During the time it takes for local wages to catch up with productivity growth, the nation can have an important, albeit perhaps only temporary, comparative advantage in crucial areas of production.

Employees of U.S. firms that suddenly find themselves at a comparative disadvantage in international markets can face massive problems of adjustment. Constant turmoil can lead not only to personal hardship but lead to enormous inefficiencies. Trade has left entire communities in areas of the rust belt and textile production regions of the South with no major employer and little time to adjust. Adjustment costs can be so large that they overwhelm the long-term benefits.

While the costs of rapid transformation do not undermine the clear benefits of expanding trade, they do provide a justification for developing a trade policy that can ensure a graceful transformation. Investments in retraining, and other programs designed to give individuals and communities an opportunity to benefit from transformation, can play a key role in ensuring that the theoretical benefits of expanded trade become real benefits.

Rapidly expanding trade can lead to a variety of other problems not easily measured in economic terms:

- **Loss of Control Over the Domestic Economy.** The sheer volume of U.S. trade in relation to the size of the domestic economy severely constrains the ability of the United States to use standard macroeconomic tools unilaterally to manage the economy. Attempts to stimulate growth through domestic spending may serve only to stimulate imports. Unilateral efforts to change or to control the exchange rate are also extremely difficult. The extent to which this loss of control translates into disruption depends heavily on the degree of cooperation among major trading partners, or lack thereof.

  In an economy without foreign trade, increased domestic spending can only be met through expanded domestic production. The regulating system is automatic: consumption increases until labor shortages drive up prices. The government can intervene to "fine tune" the economy by adjusting its spending. In an open international economy, however, increased spending can be achieved through increased imports. The regulating system becomes international in scope and options for unilateral government control become much more limited.

  The volume of international commerce in fields like banking and telecommunications mean that decisions that were once made primarily for domestic reasons here and abroad now have a significant influence on international trade. With billions of dollars flowing daily through international financial markets, inappropriate coordination of international regulation can be dangerous as well as inefficient.

The limits of unilateral control may be particularly great in times of crisis, as the international stock market crash of October 1987 proved with disturbing clarity. Such factors as a sudden loss of confidence in the U.S. economy leading to capital flight, a precipitous decline in the value of the dollar, or sudden changes in a major nation's attitude toward free trade could precipitate an acrimonious chain reaction of retaliation and panic unless sound measures are in place to coordinate domestic reactions.

- **Problems of Equity.** For reasons just discussed, it is entirely possible that while trade could increase average wealth in the United States, it can have a strong effect on the distribution of wealth and income. Evidence presented in chapter 8 suggests, for example, that in recent years trade has disadvantaged male workers with craft skills, while advantaging managers and scientists.
- **National Security.** A productive and innovative domestic economy is essential for the maintenance of American defenses. Recent evidence of declining U.S. capabilities in microelectronics, advanced materials, and other strategic areas calls into question America's ability to rely on domestic suppliers for state-of-the-art technology. Military procurement is forced to make the difficult choice between buying an American product or buying the best product. Decisions of this kind also cast doubt on U.S. ability to use technology to offset East Block advantages in manpower and other resources. (Comfort perhaps can be taken from the fact that the East is probably even less efficient than the United States in exploiting new technology, but this is scarcely a sound basis for security.) This issue is explored in greater detail in chapter 14.

  Trade may also affect security by creating such high levels of dependence on foreign suppliers that overall U.S. flexibility in foreign affairs can be compromised. U.S. dependence on imported oil proved disastrous this past decade, and could well be disastrous again. A $50 billion increase in oil imports (measured in constant 1982 dollars) is likely by the turn of the century. A case can be made that loss of domestic capacity in steel and other materials can also lead to difficulties in periods of high international stress.

It is necessary to distinguish problems actually *caused* by imperfect trade policy from problems simply *revealed* by free trade. A nation unable to discipline domestic consumption, or losing the ability to innovate because of excessive shortsightedness and self-interest, is unlikely to find its problems easily corrected by changes in exchange rates or explicit manipulation of imports. Indeed, sheltered from the pressures of trade, a nation losing its ability to innovate may simply find itself falling more rapidly behind the world state-of-the-art.

There is no simple formula for ensuring that free trade works to the advantage of the United States, while avoiding the many problems that trade can create. Fiscal policy and strategies for supporting research may affect trading patterns as powerfully as measures affecting trade more directly. Chapter 14 explores options in a variety of different areas.

Chapter 8
The Framework of U.S. Trade

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Chapter 8

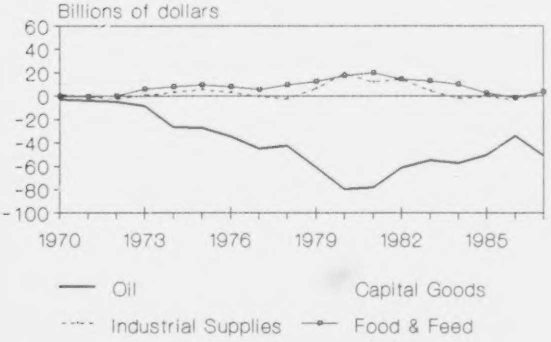
The Framework of U.S. Trade

The previous chapter looked closely at how new forces have linked trade into domestic production recipes. The present discussion takes the analysis a step further by tracing national trends in the volume and composition of trade. Trends point to a potentially serious decline in the ability of the United States to compete in the export of highly sophisticated manufactured products.

Both U.S. imports and U.S. exports have grown dramatically during the past 15 years. The oil price shocks, which nearly doubled the value of U.S. imports during the 1970s, simply accelerated a trend that began in the late 1960s and continued after oil prices fell. In 1960, the combined value of imports and exports accounted for 10 percent of the U.S. gross national product (GNP). By 1984, this had risen to 22 percent. Since imports have grown much faster than exports since 1980, the United States now experiences its largest trade deficit since systematic records began in 1929. The Nation consumed 2.7 percent more than it produced in 1987.

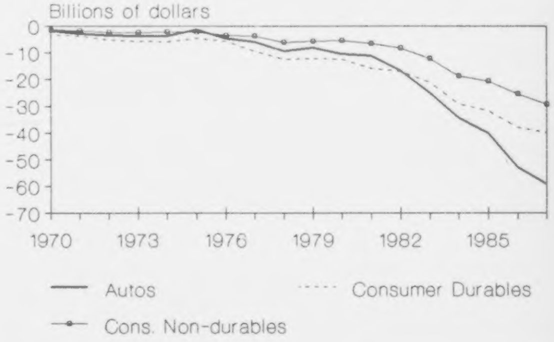
Figures 8-1 and 8-2 indicate that this deterioration is not limited to a single sector of the economy. The problem affects both consumer and industrial goods. In the category of industrial goods, the only improvement in the trade balance is in oil. There has been a trade deficit in oil since the early 1970s, but the value of oil imports declined because of falling oil prices. In the other sectors (capital goods, industrial supplies, and food & feed), healthy trade balances of the 1970s have been sharply eroded since 1980. Similar trends are noticeable in trade in consumer goods. The small deficits of the 1960s in automobiles and other consumer goods have deteriorated into large deficits. A small trade surplus in services reduces, but far from eliminates, the large merchandise trade deficit.

Figure 8-1.-Trade Balance in Industrial Goods (current dollars in billions)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 4.3.

Figure 8-2.-Trade Balance in Consumer Goods (current dollars in billions)



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 4.3.

TRADE BALANCES

In principle, economic forces demand that trade between nations be in balance over the long term. An efficient and free system of barter would adjust exchange rates, domestic wages, and/or interest rates to compensate for asymmetric trade flows. The practical world of trade, however, remains dominated by stubborn forces of nationalism, political instability, and wildly varying programs for managing domestic economies and international trade. Simple arithmetic shows that if the U.S. Government spends more than it takes in as taxes or U.S. firms invest more than they can acquire from U.S. savings—in other words, if U.S. consumption exceeds U.S. production—the difference must be made up by borrowing from abroad (as shown in table 8-1).[1] A nation must either have a current trade account in approximate balance over the long run or find a way to live on perpetually expanding credit.

Heavy U.S. reliance on foreign capital is unexpected given the history of other economic leaders. For example, when England became a "service" economy during the latter part of the 19th century, it did so primarily by lending money to American businesses and other foreign firms rather than by borrowing from the rest of the world.

The United States has been a net debtor to the rest of the world since the spring of 1984, and by 1985 became one of the world's largest borrowers, owing nearly $110 billion. By the end of 1986, the United States owed $263.5 billion.[2] The debt is now increasing at approximately $150 billion per year. By the end of the 1980s, the United States is likely to owe at least $600 billion—a sum larger than all non-defense government expenditures made in 1987. Finding a way to slow the growth of foreign debt, and perhaps even to repay some of the principle, will be a formidable challenge in a period when:

- the United States faces increasing competition in technologically sophisticated products and raw materials (like agricultural products) that once easily earned foreign currency;
- declines in U.S. and non-OPEC (Organization of Petroleum Exporting Countries) petroleum production will require significant increases in the share of petroleum imports from Arab OPEC nations;
- as much as $35 billion per year must be spent simply to repay the interest on foreign capital investment;[3]
- the widespread availability of advanced agricultural technology is reducing world demand for U.S. agricultural products, and many former U.S. customers in developing nations are facing staggering debt problems of their own; and
- key parts of America's production base are increasingly owned by foreign management.

Table 8-1.—U.S. Trade Balances and Foreign Investment in the United States, 1986
(billions of dollars)

Total payments to foreigners	**−143.9**		
Net imports of goods and services	−105.5		
—Imports		−481.7	
—Exports		376.2	
Of which, net factor income[a] is:			33.8
—Imports			−52.3
—Exports			86.1
Other payments to foreigners	−38.3		
—Transfer payments (net)		−15.7	
—Interest paid by government		−22.6	
Net Foreign Investment in the United States	**143.9**		
(domestic spending less domestic production)			
Government deficit	147.8		
Private domestic savings less investment	−8.8		
Of which:			
—Gross private savings		−679.8	
—Gross private domestic investment		671.0	
Statistical discrepancy	4.9		

[a] Direct investment income, interest income, dividend income, labor income (not including U.S. Government interest payments to foreigners).

NOTE: Numbers may not add due to rounding.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, July 1987, Tables 4.1 and 5.1.

Why is America able to continue borrowing under these conditions? The answer is political as well as economic. Affluent classes in Hong Kong or Latin America choose U.S. investments because of concern about the long-term security of wealth kept at home. The Japanese invest in U.S. manufacturing to escape current and anticipated trade sanctions.

Unlike shifts in the underlying sources of competitive advantage in international product markets, capital flows can change as rapidly as acts of political will. With politics rather than economics at work, self-correcting forces may not operate. A collapse of confidence in the United States as a debtor, for example, could trigger panic in world markets and lead to a catastrophic adjustment rather than a graceful one.

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[1] In formal terms:

$$\begin{aligned}[\text{Exports} - \text{Imports}] &= [\text{Production} - \text{Consumption}]\\ &= [\text{Taxes} - \text{Government Spending}]\\ &\quad + [\text{Savings} - \text{Investment}]\end{aligned}$$

[2] Russell B. Scholl, "The International Investment Position of the United States in 1986," *Survey of Current Business*, vol. 67, No. 3, June 1987, pp. 38-45.

[3] Stuart Auerbach, "U.S. Foreign Debt Skyrockets to $263 Billion," *The Washington Post*, June 24, 1987, p. B2.

If U.S. foreign debt expands too rapidly, the logic of investment in the United States must fail. Unless the Nation finds a way to export on the basis of high productivity and innovative products, however, the remedies available (significant increases in interest rates, a continued drop in the value of the dollar, declining U.S. wage rates, or a large reduction in imports) will involve a significant decline in U.S. living standards. Even this course can create problems —barring unexpected growth in world markets, the United States can only restore balanced trade by recapturing markets for manufactured products in areas now held by Japan, West Germany, and even some developing nations. Combined with reduced U.S. imports, this could create economic instability abroad and frustrate development plans at home.[4]

Basic Equations

The value that flows across international borders can be divided into three categories:

1. the "current account," which includes trade in goods and services from "producing industries" and returns on foreign investment (the "invisible" flow of funds);
2. the "capital account," which is the change in a nation's assets abroad and foreign assets in the nation, both direct and indirect, including purchases of bonds, stocks, and parts of firms; and
3. flows of value that do not appear in any account—for example, the value of technology available in the open literature or purchased at low cost through a U.S. education, and the value of illegal shipments.

In 1986, net U.S. payments to foreigners were $143.9 billion (again see table 8-1). This amount was precisely equal to, and thus offset by, foreign investment in the United States. The United States required this amount of investment because net private savings of $8.8 billion were combined with net government borrowing of $147.8 billion.[5] In other words, if Americans consume more than they produce, the difference must be borrowed from foreigners. The inescapable arithmetic of these accounts indicates that balanced trade requires both more U.S. exports relative to imports and more domestic saving relative to expenditures.

Capital Accounts

The capital flowing into the United States has taken a variety of forms, including increases in investments in real assets such as land and buildings, establishment of foreign subsidiaries and joint ventures, and portfolio investments in equities, corporate bonds, and short- and long-term government securities (see table 8-2). Capital flows into the United States continued even through the dollar's rapid decline in value during 1986 and 1987.

International movement of capital has been greatly facilitated by new telecommunications technology, which permits a firm in Japan to examine markets in New York, Frankfurt, Paris, Zurich, Chicago, and Singapore as easily as it examines markets in Tokyo. Gradual movement toward deregulation of financial markets in a variety of nations has contributed to this flexibility. The combination of instantaneous communication, internationally shared financial information, and relatively unregulated markets provides an unprecedented opportunity to increase the productivity of capital throughout the world. It also introduces an unprecedented amount of volatility into capital markets and weakens any single nation's ability to control international financial flows.

Of the change in U.S. investment abroad between 1984 and 1985, 36 percent was in the form of private direct investment. By contrast, only 11 percent of net foreign investment in the United States was direct investment. Nearly 60 percent of the 1985 increase in private foreign investment in the United States was in the form of bank loans, stocks, or treasury bonds. In 1985, $25.5 billion worth of treasury bonds were purchased by foreigners; thus, roughly one-fifth of the U.S. Government's budget deficit in 1985 was *directly* financed from abroad.

International flows of capital have blurred the distinction between "U.S." and "foreign" firms. As a result, tracing the flow of trade dollars in national accounts may no longer provide a sound guide to changes in economic power. Multinational firms have major holdings in the United States, whose production is not counted as imports. Conversely, foreign firms may be partly owned by U.S. multinationals: 40 percent of the "Japanese" firm Isuzu is owned by General Motors.

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[4] Lester C. Thurow and Laura D. Tyson, "The Economic Black Hole," *Foreign Policy*, No. 67, summer 1987, pp. 3-21.

[5] The National Income and Product Accounts incorporate a statistical discrepency in calculating net foreign investment of $4.9 billion. See table 8-1.

In 1985, 39 percent of U.S. investment abroad was in Western Europe and Japan, while 76 percent of new (1984 to 1985) foreign investment in the United States was by these nations (see table 8-3). Even the struggling Latin American nations significantly increased their investment in the United States between 1984 and 1985.

Table 8-2.—U.S. Investment Abroad and Foreign Investment in the United States by Type of Investment: 1984 and 1985 (billions of dollars)

Investment type	All nations		
	1985 total	1984-85 increase	Japan 1985 total
U.S. assets	952.4	54.2	56.3
Official assets	130.6	11.0	4.4
Private assets	821.8	43.1	51.6
Direct investment	232.7	19.7	9.1
Bonds	73.4	11.4	1.5
Stocks	40.7	12.8	3.9
Other[a]	474.9	−0.7	37.1
Foreign assets in U.S.	1,059.8	166.0	101.8
Official assets	202.3	3.2	N.A.
Private assets	857.5	162.8	N.A.
Direct investment	183.0	18.4	19.1
U.S. Treasury Bonds	83.8	25.5	N.A.
Private bonds	81.8	49.1	8.6
Stocks	125.9	30.1	1.9
Other[a]	382.9	39.7	N.A.

[a] Primarily loans from private banks.

N.A. = Not available.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "The International Investment Position of the United States in 1985," *Survey of Current Business*, vol. 66, No. 6, June 1986, p. 27.

Table 8-3.—U.S. and Foreign Investment by Region, 1984 and 1985 (billions of dollars)

	Western Europe	Canada	Japan	Latin America	Other	Total
1984:						
U.S. assets abroad	272	115	48	267	196	898
Foreign assets in United States	423	58	68	189	156	894
Net	−151	57	−19	78	39	4
1985:						
U.S. assets abroad	317	119	56	266	195	953
Foreign assets in United States	515	66	102	212	165	1,060
Net	−198	53	−46	54	30	−107

NOTE: Numbers may not add due to rounding

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "The International Investment Position of the United States in 1985," *Survey of Current Business*, vol. 66, No. 6, June 1986, p. 27.

TRADE COMPOSITION

Trends

The change in the *volume* of trade relative to the size of the U.S. economy has also been accompanied by a change in the *composition* of trade—the kinds of goods and services traded. Changes in the composition of trade can be a cause for alarm, since they may reveal changes in the competitive status of the national economy. It now seems clear that the factors driving post-war U.S. dominance in productivity, such as higher levels of education, easier access to capital, and possession of technologically advanced processes, have eroded. Some part of this loss was inevitable given the fact that it is easier to catch up with a technological leader than it is to forge into untested new areas and succeed. In addition, a technical leader is unable to recover the real value of exported technology or training. To some extent, however, the loss has also been the result of complacency and mismanagement in U.S. industries.[6]

With the advantages of hindsight, the convergence of U.S. and foreign living standards was also predictable given the incentives for post-war recovery and international access to U.S. markets. What was not anticipated, however, was the weakening of the "product cycle," which had once seemed to guarantee that U.S. leadership would be virtually self-perpetuating.[7]

The logic of the product cycle was difficult to challenge. U.S. producers, facing the world's most affluent markets, paying the highest wages, and with access to the largest number of highly skilled workers, had a natural incentive to be the first in the development of sophisticated new products and technologies that substituted capital for comparatively expensive labor. Production systems developed originally for the advanced U.S. economy were eventually perfected to the point where they could be operated by labor available in less affluent economies and transferred as U.S. producers moved to begin yet another cycle.

It is conceivable that the United States could have continued to lead Japan and Europe indefinitely, with new products continually replacing the old in the U.S. export mix. The characteristics of the U.S. market, however, have grown less distinctive over time. The internationalization of financial markets has tended to equalize the cost of capital throughout the world. The traditional product cycle was further weakened by a convergence in wages, and a number of nations may now actually have greater incentives to introduce labor-saving equipment than the United States. U.S. advantages stemming from inexpensive raw materials have also been reduced, by modern production systems requiring lower raw material inputs in the production recipe. Technology has also introduced many options for substituting intellectual resources for scarce or expensive energy, minerals, and other kinds of natural resources.

Large and affluent domestic markets uninhibited by interstate trade restrictions once provided unique advantages for U.S. producers. These advantages are now available to producers throughout the world. Moreover, rising incomes in Europe and Japan have narrowed the huge post-war differences in per capita GNP to the point where innovations designed for European and Japanese markets increasingly resemble those designed for U.S. markets. And new products and production technologies, coupled with growing diversity in American households, have fragmented formerly homogeneous U.S. markets in areas ranging from insurance policies to kitchen appliances. Information technology played a key role in tailoring products to highly specific markets, and in facilitating the production and delivery of large numbers of highly differentiated products without adding significantly to costs. Both of these developments have opened opportunities for foreign entry into U.S. markets.

Stripped of their unique resource and product-cycle advantages, U.S. firms may be at a relative disadvantage in applying complex and fast-moving production and product technologies. Japan and Pacific Rim nations, which have built economic expansion around exports, have developed an impressive ability to identify niche markets and promising new technologies in areas ranging from automobiles to compact-disk electronics. Moreover, they have had longer experience in finding ways to be flexible in the face of volatile world energy and resource costs (an advantage now largely invisible given low world oil prices). By 1984, the exports of U.S. manufacturing firms commonly thought of as "high technology" businesses had declined in relative importance, while gains were posted by most natural resource enterprises.

Although shifts in the composition of U.S. trade indicate that the United States has lost leadership in technological products, they cannot be interpreted to indicate that the United States has now moved to a position of follower in the product cycle. A position of continued leadership would presumably be indicated by trade patterns generating large numbers of technologically sophisticated jobs in the United States (engineers, scientists, supporting technical staffs, and highly skilled craftsmen), while tasks that could be reduced to relatively routine labor associated with older types of automation would move abroad. On the other hand, if the United States were reduced to a position on the second tier of the product cycle, the reverse would be true: increasing net exports of semi-skilled production jobs and decreasing net exports of jobs involving technologically sophisticated products. In fact, available data show that what is actually occurring follows neither pattern exactly.

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[6] See interview with Malcolm Baldrige, "Despite Barbs, Baldrige Hopeful on U.S. Business," *Washington Post*, Dec. 7, 1986.

[7] Raymond Vernon, "International Investment and International Trade in the Product Cycle," *Quarterly Journal of Economics*, May 1966.

Links in the chain of product development connecting research, production, and marketing prove to be some of the Nation's most fragile assets. Some links, like the connection between producers and supporting services, can be documented using the techniques described in chapter 7. Others are more difficult to follow, since they involve subtle and informal connections between engineering inspiration and familiarity with the daily problems of production.[8] If such links are lost, regaining them will not be easy. The task of rebuilding leadership is much more difficult than maintaining it, and the task of recovering competitive advantage is different than riding comfortably on the crest of a product cycle.

Loss of clear technological leadership does not mean that the United States is necessarily condemned to see its living standards reduced. It does mean that the United States can no longer take markets for granted, depend on inexpensive resources, or rely on a global reputation for making state-of-the-art products. The United States must now compete with many nations on an equal footing—taking advantage where it can by demonstrating a superior ability to make products using new technologies.

The prices of a nation's products and services today depend to a large degree on active choices of private management and the government programs that support them, rather than on traditional price differences derived automatically from natural endowments.[9] This means that the composition of a nation's trade is increasingly a function of the skill and education of its work force, and the success with which its management succeeds in converting new ideas into products and profits. These are areas in which the United States does not have an inherent comparative advantage.

Changing Comparative Advantage

If overall trade balances were restored, there would be no cause for alarm in the static picture of trade composition discussed in the previous sections—but the process by which the Nation restores this balance is of great significance. Will the United States expand exports of technologically sophisticated products and services that result in well-paying domestic jobs, or will the United States be able to compete only by exporting raw materials and comparatively low technology manufacturing? There is concern that the United States has lost critical parts of the technological infrastructure necessary to compete in many areas involving rapidly changing and advancing technologies.[10]

Some consolation can be taken from the fact that recent history provides no case in which loss of trade leadership led to an absolute decline in the living standards of the country concerned. Some countries have, of course, advanced more slowly than the leaders. The United Kingdom provides a highly visible case. Between 1870 and 1910, Britain lost its world economic leadership to Germany and the United States; its share of world manufacturing fell from 32 percent to 14 percent. Yet during this same period, per capita consumption increased 50 percent.[11] Today, England's citizens enjoy a growing standard of living and productivity, and unemployment is not strikingly higher than in more prosperous European nations.[12] Ironically, British interest in welfare grew rather than declined as the economy slowed in relative terms.

The situation could be dramatically different if the United States were forced to readjust to a lower relative status through an international financial crisis. An event such as a disastrous oil crisis, a major default of Latin debtors to U.S. banks, or a loss of confidence in fiscal management could trigger a collapse of confidence in the U.S. economy leading to capital flight. A severe domestic recession could set in, leaving the United States without any easy opportunities for stimulating the economy given the enormous budget deficits that already exist and the need to keep interest rates high to attract foreign capital. Such dramatic events could trigger real hardship and lead to drastic steps to protect U.S. markets. If U.S. multinationals were to look abroad for less expensive production opportunities, there would be a reduction in U.S. infrastructure expenditures, reducing investment in programs or institutions designed to enhance domestic productivity.

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[8] For greater elaboration of this argument, see Stephen Cohen and John Zysman, *Manufacturing Matters: The Myth of a Post-Industrial Economy* (New York, NY: Basic Books, 1987).

[9] John Zysman and Laura Tyson eds., *American Industry in International Competition* (Ithaca, NY: Cornell University Press, 1983).

[10] S. Cohen and J. Zysman, op. cit., footnote 8.

[11] Robert Gilpin, *U.S. Power and the Multinational Corporation* (New York, NY: Basic Books, 1975).

[12] William J. Baumol, "Productivity Growth, Convergence and Welfare: What the Long Run Data Show," C.V. Starr Center for Applied Economics, RR#85-27, August 1985.

Comparative Advantage Defined

Since the concept of comparative advantage will be used and critiqued throughout the following discussion, it is useful to begin by stating the basic argument. The central point is obvious and unassailable: trade between nations allows each nation to specialize in those areas where it has the greatest comparative advantage (i.e., lowest cost and/or highest productivity compared to all the other products produced by that nation). By specializing in what it does best and trading for other products and services each nation becomes wealthier than would be the case if no trade took place. Standards of living in each nation increase regardless of the difference in relative living standards before trade (see box 8-A).

Documenting Changes in U.S. Comparative Advantage

Documenting changes in comparative advantage can be difficult even in the best of circumstances. It is particularly difficult when the overall trade balance is undergoing significant changes. For a variety of reasons, trade balances turned negative in virtually every part of the economy between 1980 and 1987. This cannot imply that the United States has lost comparative advantage in every sector. Some sectors suffered more rapid declines than others.

Given the complex networks of enterprises that deliver products to consumers, it is difficult to disentangle competitiveness in one part of the network from that in another. It is also difficult to separate the productivity of one part of a production network from the performance of the network acting as an integrated whole. It is entirely possible that a comparatively low-cost manufacturer has a poor showing in international trade simply because that business is not a part of a network capable of identifying rapidly changing foreign market niches and moving aggressively to exploit advantages. Static measures, therefore, can give a misleading impression.

An index of the comparative advantage of different U.S. industries can be created by dividing the value-added a sector gained through exports in a given year by the value-added lost through exports. Businesses can be ranked by this index in any given year. Changes in the competitive status of the business can be measured by the extent to which industry positions in such a list change from year to year. Changes in competitive ranks between 1972 and 1984 can be measured by taking the ratios between the competitive index for a business in 1984 and the index for 1972. If this ratio is greater than one, the industry became more competitive between 1972 and 1984 while the reverse was true if the ratio is less than one (see table 8-4). The ratio for all industries is less than 1 since total imports grew more rapidly than total exports during the period. Businesses with ratios below the average (0.84) lost in *comparative* terms while businesses with ratios above the average gained.

Table 8-4 accounts for both direct and indirect effects of trade on the output of each business. It attempts to show only the effects of trade, eliminating changes in value-added in each business that resulted from changes in domestic final demand and in domestic production recipes. The changes shown in the table must be treated with caution since it is based on the same assumptions that led to the creation of tables 7-6 and 7-7 in chapter 7. The results are also very sensitive to the years chosen for comparison.

Almost all manufacturing enterprises in the United States lost ground during this period. Heavy declines and losses were suffered in areas where traditional product leaders should have been gaining advantage: electronic components & accessories; office, computing, & accounting machines; aircraft & parts; and engines & turbines. In addition, automobile manufacturing and apparel lost significant comparative advantage during the past decade.

With the exception of farm equipment (which has undoubtedly lost rank subsequently), only two of the

Box 8-A.—Comparative Advantage

Suppose that U.S. producers can make a radio for $30 and a computer chip for $10, while in Japan both a radio and a computer chip can be made for 600 Yen. Without trade, an American with $60 (or a Japanese with 2400 Yen) could buy one radio and three computer chips. If trade barriers are suddenly lifted, both sides will discover that they gain by specializing in the area where their comparative advantage is highest. In America one radio can be exchanged for three chips, while in Japan the exchange ratio between chips and radios is one to one. Thus, America's comparative advantage lies in chip production, and Japan's comparative advantage lies in radio production.

Suppose that after some haggling it was agreed that the American would exchange three U.S. computer chips for two Japanese radios. The American would then be able to use his $60 to buy six U.S. computer chips and trade three of them for two Japanese radios, while the Japanese would purchase four Japanese radios and trade two of them for three U.S. computer chips. After trade, both the American and the Japanese would be able to buy two radios and three computer chips with the same money that formerly purchased only one radio and three computer chips. By specializing in its area of comparative advantage the wealth of each country has increased.

While the data can be used to show that living standards in both nations would increase with trade, they cannot be used to show which nation has a higher absolute standard of living. Absolute living standards (measured in terms of quantities of goods available per hour worked) depend on the *absolute* levels of output per hour in areas where the nation has comparative advantage. This conclusion does not depend on whether Japanese earned the equivalent of $100 an hour or $0.10 an hour. Suppose that the United States could produce 18 computer chips with 18 hours of work while Japan needed 36 hours to produce 12 radios. The United States would get the same goods (radios and chips) for half as much work as the Japanese. The Japanese would, however, get more per hour worked than they would without trade.

The gap between U.S. and Japanese living standards would close if Japanese productivity approached U.S. levels. If the Japanese achieved nearly the same production costs as the United States in all products, the advantages of trade would shrink. Taking the example a step further, if the Japanese equalled the United States in their productivity of radio production but surpassed the United States in their productivity of chip manufacturing, U.S. workers would again enjoy rising living standards in that 18 hours of work could buy more than three radios and nine chips. Americans would, however, be making radios instead of chips, and the Japanese would have a higher standard of living.

The analysis does not say anything about changes in income distribution that might result from trade. If production wages are lower and working conditions less attractive in the U.S. radio industry than they are in chip production, the shift from chips to radios could benefit owners of capital and a small number of skilled engineers at the expense of production workers. Average U.S. wealth could increase, while the welfare of some groups would decline as the result of trade.

"high technology" enterprises gaining comparative rank involved electrical or metal manufacturing. Instead, gains were posted by manufacturers using chemical processes (chemical products and plastics). Of the 20 industries designated as "high technology," 15 lost rank.[13] Natural resource enterprises, led by agricultural exports that remained strong in 1984, showed consistent gains in rank. Lumber, paper, livestock, and tobacco increased their rank, as well as some Low Wage Manufacturing industries like leather tanning, miscellaneous textiles (non-apparel), and household furniture. In addition, a curious collection of enterprises such as communications, radio & TV broadcasting, and business services gained in rank. U.S. trade in ordnance and associated military equipment also gained sharply in comparative rank.

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[13] Virtually all definitions of high-technology rely on one, or both, of two indicators: "large" or above-average R&D expenditures relative to value-added or shipments; and a "high" or above-average proportion of scientists and engineers in the labor force. Examples of definitions using these criteria include New York Stock Exchange, *U.S. International Competitiveness: Perception and Reality* (New York, NY: NYSE, 1984); Michael Aho and Howard F. Rosen, "Trends in Technology-Intensive Trade: With Special Reference to U.S. Competitiveness," U.S. Department of Labor, Bureau of International Labor Affairs, Washington, DC, 1980; Regina Kelly, "The Impact of Technological Innovation on International Trade Patterns," Bureau of International Economic Policy and Research, U.S. Department of Commerce, 1977; U.S. Department of Commerce, International Trade Administration, "An Assessment of U.S. Competitiveness in High Technology Industries," 1983; Lester Davis, "Technology Intensity of U.S. Output and Trade," Office of Trade and Investment Analysis, International Trade Administration, U.S. Department of Commerce, 1985; Victoria Hatter, "U.S. High Technology Trade and Competitiveness," Office of Trade and Investment Analysis, International Trade Administration, U.S. Department of Commerce, 1985; Organization for Economic Cooperation and Development (OECD), *OECD Science and Technology Indicators II: Resources Devoted to R&D, Technological Performance and Industrial Competitiveness* and *Annex*, 1985.

While these techniques can capture some of the linkages between research and the ultimate beneficiary of the research, they are only partially successful. Linkages through capital investment are poorly captured, and the impact of government-sponsored research is not captured at all.

Table 8-4.—Industries Gaining or Losing Apparent Advantage in Trade (measured by change in the ratio of value-added gained due to exports to value-added lost due to imports between 1972 and 1984)

NOTE: An index >1 means export/import ratio increased between 1972 and 1984, an index <1 means that the export/import ratio declined during the same period.
*1984 index = (1984 exports) ÷ (1984 imports)

Industry	1984 index* / 1972 index	Industry	1984 index / 1972 index
Amusements	0.49	Paperboard containers and boxes	0.88
Miscellaneous manufacturing	0.50	Finance and insurance	0.89
Apparel	0.51	Glass and glass products	0.89
H Construction and mining machinery	0.57	Rubber and miscellaneous plastic products	0.89
H Electronic components and accessories	0.59	Real estate and rental	0.89
H Office, computing, and accounting machinery	0.61	Stone and clay products	0.90
Miscellaneous fabricated textile products	0.61	Maintenance and repair construction	0.90
H Metalworking machinery and equipment	0.61	H Plastic and synthetic materials	0.91
H Special industry machinery and equipment	0.63	Primary nonferrous metals manufacturing	0.91
Broad and narrow fabrics, yarn, and thread mills	0.63	Crude petroleum and natural gas	0.92
Other furniture and fixtures	0.65	Health, education, & social services and nonprofit organizations	0.92
H Aircraft and parts	0.66	New construction	0.96
Motor vehicles and equipment	0.67	Forestry and fishery products	0.96
H Materials handling machinary and equipment	0.70	Coal mining	0.96
Screw machine products and stampings	0.71	Miscellaneous electrical machinery and supplies	0.97
H Engines and turbines	0.71	Communications, except radio and tv	0.97
H Optical, ophthalmic, and photographic equipment	0.71	Business services	0.98
H Service industry machines	0.71	Radio and TV broadcasting	0.98
H Scientific and controlling instruments	0.72	Tobacco manufacturers	0.99
Footwear and other leather products	0.74	Chemical and fertilizer mineral mining	1.00
H Electric lighting and wiring equipment	0.74	Household appliances	1.00
H General industrial machinery and equipment	0.76	Transportation and warehousing	1.00
Federal Government enterprises	0.78	Paper and allied products, except containers	1.01
Primary iron and steel manufacturing	0.80	H Chemicals and selected chemical products	1.05
H Drugs, cleaning and toilet preparations	0.81	Wood containers	1.05
Hotels; personal and repair services (excluding auto)	0.81	Printing and publishing	1.06
Paints and allied products	0.81	Petroleum refining and related industries	1.07
Other fabricated metal products	0.81	Metal containers	1.08
Electric, gas, water and sanitary services	0.82	Ordnance and accessories	1.12
Wholesale and retail trade	0.82	Lumber and wood products, except containers	1.12
H Radio, TV and communication equipment	0.83	Household furniture	1.14
State and local government enterprises	0.84	Nonferrous metal ores mining, except copper	1.15
Average of all industries	**0.84**	Miscellaneous textile goods and floor coverings	1.18
H Miscellaneous machinery, except electrical	0.84	H Farm and garden machinery	1.18
Heating, plumbing and structural metal products	0.84	Leather tanning and finishing	1.23
H Electric industrial equipment and apparatus	0.85	Food and Kindred Products	1.29
Automobile repair and services	0.86	Stone and clay mining and quarrying	1.32
Eating and drinking places	0.86	Livestock and livestock products	1.36
		Other transportation equipment	1.37
		Agricultural, forestry and fishery services	1.43
		Iron and ferroalloy ores mining	1.58
		Other agricultural products	1.60

How To Read This Table: In 1984, the ratio of value-added in "electronic components and accessories" gained from exports to value-added lost from imports was 59 percent of the ratio calculated using 1972 trade patterns.

H = "high-technology" manufacturing sectors, using the categorization suggested in Robert Z. Lawrence, *Can America Compete* (Washington, DC: The Brookings Institution, 1984), p. 148.

SOURCE: Office of Technology Assessment, based on U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, Input-Output Tables: 1980, unpublished; and U.S. Department of Labor, Bureau of Labor Statistics, 1984 trade estimates rebased into 1980 dollars, unpublished.

A different way of viewing the change is to examine the ratios of jobs created to jobs lost by occupation. Table 8-5 shows that, as before, the greatest losses are concentrated in direct manufacturing occupations, while trade seems to work to the advantage of service occupations and other occupations that indirectly support manufacturing. Engineers and engineering technicians appear to be losing ground as rapidly as the craftsmen and laborers that their engineering supports. The data reveal a sharp break between the fate of individuals labeled "engineers" and those labeled "scientists." Trade worked to the advantage of scientific professions more than it worked to the disadvantage of engineering. Computer operators, communication specialists, and a variety of other occupations closely tied to the sophisticated management networks described in Part II all appear to be associated with enterprises gaining in comparative advantage.

Numerous studies of U.S. trade argue that technology plays an important role in the determination of U.S. comparative advantage.[14] The analysis presented thus far, however, indicates that technology-intensive firms have lost ground over the past twelve years compared with other U.S. industries. The great-

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[14] D.B. Keesing, "The Impact of Research and Development on United States Trade," *Journal of Political Economy*, vol. 75, February, 1967; W.H. Gruber and R. Vernon, "The R&D Factor in a World Trade Matrix," in R. Vernon (ed.) *The Technology Factor in International Trade* (New York, NY: Columbia University Press, 1970); Thomas C. Lowinger, "The Technology Factor and the Export Performance of U.S. Manufacturing Industries," *Economic Inquiry*, vol. 13, June 1975; Robert E. Baldwin, "Determinants of Trade and Foreign Investment: Further Evidence," *Review of Economics and Statistics*, vol. 61, No. 1, 1979; Michael Aho and Howard F. Rosen, op. cit., footnote 13.

Table 8-5.—Occupations Gaining or Losing Apparent Advantage in Trade (measured by change in the ratio of jobs gained due to exports to jobs lost due to imports between 1972 and 1984)

NOTE: An index >1 means export/import ratio increased between 1972 and 1984, an index <1 means that the export/import ratio declined during the same period. Jobs refer to wage and salary employees only.

Occupation category	Net 1984 jobs / Net 1972 jobs
Hand working occupations, including assemblers and fabricators	0.65
Machine setters, set-up operators, operators, and tenders	0.67
Engineers	0.68
Precision production occupations	0.68
Engineering and science technicians and technologists	0.71
Personal service occupations	0.73
Blue collar worker supervisors	0.73
Teachers, librarians, and counselors	0.74
Technicians, except health, engineering and science	0.74
Material records, scheduling, dispatching, and distribution	0.75
Management support occupations	0.76
Mail and message distribution workers	0.77
Average for all occupations	**0.77**
Writers, artists, entertainers, and athletes	0.78
Managerial and administrative occupations	0.78
Computer operators and peripheral equipment operators	0.79
Records processing occupations, except financial	0.79
Food and beverage preparers and service occupations	0.79
All other professional, paraprofessional, and technical	0.79
Helpers, laborers, and material movers, hand	0.80
All other service occupations	0.80
Mechanics, installers, and repairers	0.80
Financial records processing occupations	0.80
Other clerical and administrative support workers	0.80
Secretaries, stenographers, and typists	0.80
Extractive and related workers, including blasters	0.80
Natural, computer, and mathematical scientists	0.80
Social, recreational, and religious workers	0.80
Cleaning and building service occupations, except private household	0.82
Construction trades	0.83
Duplicating, mail, and other office machine operators	0.83
Marketing and sales occupations	0.85
Protective service occupations	0.85
Information clerks	0.86
Adjusters and investigators	0.86
Transportation and material moving machine and vehicle operators	0.87
Communications equipment operators	0.87
Health technicians and technologists	0.87
Plant and system occupations	0.88
Health service and related occupations	0.89
Social scientists	0.91
Lawyers and judges	0.92
Health diagnosing and treating occupations	0.96
Architects and serveyors	1.01
Agriculture, forestry, fishing, and related occupations	1.50

How To Read This Table: In 1984, the ratio of jobs in "hand working occupations" gained from exports to jobs lost from imports was 65 percent of the ratio calculated using 1972 trade patterns.

SOURCE: Office of Technology Assessment, based on U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, Input-Output Tables: 1980, unpublished; U.S. Department of Labor, Bureau of Labor Statistics, "Employment Requirements," unpublished; and 1984 trade estimates rebased into 1980 dollars, unpublished.

est loss in value-added was in precisely those areas one would expect to find gains in value-added if the United States were to remain at the head of product cycles in emerging technologies. On the other hand, the United States appears to be gaining advantage in businesses heavily dependent on raw materials and in labor-intensive manufacturing—precisely the areas one would expect to be losing ground to developing nations.

Between 1972 and 1984, the United States lost a significant volume of high-technology exports primarily because of rapidly increasing imports. Overall, the United States still retained a $4 billion trade surplus in technology-intensive businesses in 1985. During the first half of 1986, however, this became a trade deficit of $1.3 billion.[15] A recent study by the U.S. Department of Commerce found that the technology intensity of U.S. exports remained unchanged from 1972 to 1984, while Japan's rose sharply. The U.S. lead was cut in half.[16]

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[15] Quick, Finan & Associates, Inc., "The U.S. Trade Position in High Technology: 1980—1986," Report Prepared for the Joint Economic Committee of the U.S. Congress, Washington, DC, October 1986, p. 8. The U.S. Department of Commerce defines "high technology" as including industrial organic chemicals; plastic materials and synthetic resins; synthetic rubber; synthetic and other manmade fibers, except glass; drugs; ordnance and accessories, except vehicles and guided missiles; engines and turbines; office, computing, and accounting machines; radio and television receiving equipment, except communication types; communication equipment; electronic components and accessories; aircraft and parts; guided missiles and space vehicles and parts; measuring, analyzing, and controlling instruments; photographic, medical, and optical goods; and watches and clocks, except instruments for the measuring and testing of electricity and electric signals.

[16] Lester A. Davis, "Technology Intensity of U.S., Canadian, and Japanese Manufactures Output and Exports," presented at the Industrial Colloquium on Oligopolies, Technological Innovation, and International Trade, October 1987.

LONG-TERM TRENDS

The Convergence Club

Is it inherent in the nature of things that leaders should sooner or later falter? It seems difficult for any nation to maintain indefinitely a consistently large lead in productivity. In spite of radically different national economic strategies and two world wars, productivity growth rates during the past 100 years are almost perfectly correlated with the degree to which a nation was trailing the most productive nations in 1870. In other words, the further behind in 1870, the more rapidly the nation caught up.[17] Between 1870 and 1979, differences in the productivity of 16 industrial nations fell by more than a factor of 2.[18]

Why Leaders Falter

Leaving aside the role played by national policy in encouraging or discouraging investment and innovation, there are a variety of reasons why an economic leader may fail to grow as rapidly as its followers:

1. An obvious advantage is gained by imitating something that has already been shown to be possible. Even if the imitator is not able to obtain the technology and knowhow required to match the leader, the knowledge that a product or process is possible has already eliminated the need to pursue a variety of dead ends.

   The avenues for transferring technology are spectacular, and continue to grow as communication and transportation technologies improve and as multinational corporations become more highly interdependent and familiar with each other's operations.[19] At a minimum, this process means that the opportunity to capture the economic rents due to innovation (and thereby the incentives to undertake innovation) diminish sharply. The innovator's investment in research, therefore, becomes a public good. Indeed, the imitator's concentration on production technology may well result in a second generation product that is higher in quality and less expensive than the original.

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[17] Baumol, op. cit., footnote 12.

[18] Angus Maddison, "Phases of Capitalist Development," in Baumol, op. cit., footnote 12.

[19] Raymond Vernon, "Coping With Technological Change: U.S. Problems and Prospects,"in Bruce R. Guile and Harvey Brooks, ed., *Technology and Global Industry* (Washington, DC: National Academy Press, 1987).

However, imitation without the help of the group developing the innovation requires an extremely sophisticated research infrastructure. It is apparent that firms conducting their own research are more likely to recognize useful innovations and apply them practically than firms lacking such an infrastructure. The rate of technology flow across borders must increase as more countries develop this ability.

2. It seems to be easier for a rapidly developing nation to take risks with innovations than it is for an established producer facing relatively stagnant markets where any innovation must replace an existing system.[20] Established firms in the United States with a high level of retained earnings face three options for investment: further domestic investment that could saturate markets and drive down profits, product diversification and innovation (a high risk strategy), and movement abroad in an experienced product line—a choice commonly preferred since it is relatively free of risks.[21]

   Leaders attempting to anticipate the direction of consumer demand in areas that require speculation about unknown patterns of consumption are likely to behave more conservatively than firms concentrating on capturing well-understood markets, but "the simple attitude of waiting" can make leaders less aggressive in exploiting new markets and technical innovations.[22]

3. Leaders may simply fail because of complacency—for example, if they assumed that all technology worth paying attention would be developed in the United States, would be freely available for purchase in the United States, and would be published in English. Trade grew rapidly during the 1970s, but on balance this tended to favor U.S. manufacturing exporters; OPEC nations, and Latin American nations expanding through purchases of U.S. capital equipment, created strong markets for U.S. products. The United States was not prepared for the explosion of competition based on sophisticated technology such as the one now occurring in Asia.

   While it is difficult to prove the case, numerous anecdotes suggest that at least part of America's loss of export markets resulted from an assumption that consumers around the world longed to imitate U.S. consumption patterns, and that world markets would largely follow the path led by U.S. consumers. The corollary was that there was no need to tailor products specifically for export or to make a special effort to market them abroad. This argument held that the very superiority of U.S. goods, and their association with U.S. economic leadership, would be adequate to promote sales.

   The United States appears to have been unprepared for a world in which many of the most basic product and process innovations, or at least innovations available at a reasonable cost for producers and consumers, would originate in Japan and elsewhere.

While trading patterns have been changing for years, technological innovations and newly sophisticated international management strategies may have accelerated the process. On-line international data networks already allow global access to current information in some areas, while new telecommunications equipment permits tighter global integration of production and even research and development. More generally, declining communications and transportation costs have contributed to an increase in the knowledge and skill base outside the United States, a development visible in the rapid growth of trained engineers, financial experts, and managers in newly industrializing countries. The result is a more competitive economic environment in which the life cycle of any product has been dramatically shortened.

One study has shown that U.S. firms introduce new products into foreign markets sooner than they have in the past (see table 8-6).[23] Another study examined data on 65 technologies to see whether the proportion of technologies transferred within 5 years of development was greater during 1969-78 than during 1960-68.[24] This study concluded that for tech-

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[20] Andrew Sayer, "New Developments in Manufacturing and Their Spatial Implications," working paper No. 49, University of Sussex, Department of Urban and Regional Studies, Sussex, England, October 1985.

[21] A. Maddison, op. cit., footnote 18.

[22] L.L. Pasinetti, *Structural Change and Economic Growth: A Theoretical Essay on the Dynamics of the Wealth of Nations* (Cambridge: University Press, 1981).

[23] William H. Davidson, *Experience Effects in International Investment and Technology Transfer* (Ann Arbor, MI: UMI Research Press, 1980).

[24] E. Mansfield and A. Romeo, "Technology Transfer to Overseas Subsidiaries of U.S.-based Firms" *Quarterly Journal of Economics*, vol. 95, 1980, pp. 737-750.

Table 8-6.—Change in Transfer Rate for 954 Products (by period of U.S. introduction)

Period of U.S. Introduction	Number of products	% First introduced abroad in: 1 year or less	2 to 3 years	4 to 5 years	6 to 9 years	10 or more years
1945-49	174	8.0%	9.2%	8.0%	16.7%	46.6%
1950-54	151	8.6	9.3	12.6	25.8	28.4
1955-59	153	8.5	15.7	17.6	23.6	19.6
1960-64	185	23.2	19.4	14.6	13.5	9.9
1965-69	170	28.2	16.5	11.8	7.1	N.A.
1970-75	121	32.2	18.1	N.A.	N.A.	N.A.
Total	954	17.7%	14.1%	11.7%	14.7%	18.1%

How To Read This Table: Between 1945 and 1949, U.S. firms transferred 174 products to foreign countries. Of these, 8 percent were transferred within a year of their introduction in the United States, while 46.6 percent were introduced ten or more years after they were used in the United States. Between 1970 and 1975, 32.2 percent of the products examined were used aborad within a year of their introduction in the United States.

N.A. = Not available.

SOURCE: William H. Davidson, *Experience Effects in International Investment and Technology Transfer* (Ann Arbor, MI: UMI Research Press, 1980).

nologies transferred to subsidiaries in developed countries there was a sharp increase in the transfer of recent technologies, from 27 percent in 1960 to 75 percent in 1968-78—suggesting a marked shortening of the product cycle among the states belonging to the Organization for Economic Cooperation and Development (OECD). For technologies transferred to subsidiaries in developing countries or through other channels, including licensing and joint ventures, the sample showed no statistically significant trend toward more rapid diffusion. At a more general level, W.W. Rostow has argued that the disappearance of the technological backlog is one of the most important factors accounting for the rapid growth of "late developers."[25] The "rich," on the other hand, slow down because of the difficulties in continually operating at the technological frontier.

One result of this faster rate of diffusion is that fewer areas of technology are dominated by a small number of firms. It is true that in many high-technology industries, the number of firms found in any one country has probably declined through mergers, creating the impression of growing concentration at the global level. However, this has probably been offset by the process of international diffusion that spurs new entrants. The number of seemingly independent sources of technology in most high-technology industries appears to have grown, which in turn enhances the bargaining power of those firms and of countries seeking effective transfers. This has been demonstrated by a study of the Brazilian petrochemical industry,[26] and in more aggregate data.[27]

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[25] W. W. Rostow, *Why the Poor Get Rich and the Rich Slow Down* (Austin, TX: University of Texas Press, 1980).

[26] Francisco Sercovich, "State Owned Enterprises and Dynamic Comparative Advantages in the World Retro-Chemical Industry: The Case of Commodity Olefins in Brazil," Harvard Institute for International Development, Discussion Paper 96, Cambridge, MA, May 1980.

[27] Robert B. Stobaugh, "The Product Life Cycle, U.S. Exports and International Investment," PhD Dissertation, Harvard University, Cambridge, MA, 1968.

FOUR HYPOTHESES ABOUT THE FUTURE

At some point the United States must find a way to get trade imbalances back to manageable levels. It will need to do so while imports of petroleum increase and while several key areas of past U.S. export surpluses, such as agricultural products, are unlikely to provide the kind of revenue they have in the past. The central issue is whether the trade balance is restored in a way that provides growing opportunities for good jobs in the United States or whether it is restored through acceptance of declining living standards. U.S. ability to assimilate and apply technology to profitable commercial applications will play a key role in determining the Nation's economic future.

Since the future of world trade depends on many choices made here and abroad, it is foolhardy to construct a definite forecast for the future. But it is useful to explore some illustrative possibilities, as outlined below.

All of the future scenarios assume an eventual return to a balance in total trade—imports equaling exports. This is not meant to imply that in the year 2005 merchandise imports will exactly equal exports, but rather that all trade—merchandise, services, and the net payment of income on investments both in this country and abroad—will be in balance.

All of the scenarios make use of U.S. Department of Energy projections for oil imports. What differs in each scenario is the role and importance of different sectors of the economy in contributing to growth. Trade scenarios for both 1.5 percent and 3 percent GNP growth rates are given in tables 8-7a and 8-7b; the scenarios are not meant to be predictions of the future, but to provide a sensitivity analysis of how trade could affect the U.S. economy during the next two decades. Assumptions leading to the 3 percent scenarios are described below (the slower growth rate assumptions can be deduced by analogy):

Table 8-7a.—3 Percent Growth Trade Scenarios

Sector	Caesar scenario Imports	Caesar scenario Exports
Natural resources and construction	16%	14%
Manufacturing	49	51
Services	35	35
Total (percent)	100	100
Total ($ billions)	$980	$980
	Banana scenario Imports	**Banana scenario Exports**
Natural resources and construction	10%	16%
Manufacturing	55	49
Services	35	35
Total (percent)	100	100
Total ($ billions)	$980	$980
	Drucker scenario Imports	**Drucker scenario Exports**
Natural resources and construction	18%	6%
Manufacturing	50	41
Services	32	52
Total (percent)	100	100
Total ($ billions)	$510	$510
	Trend scenario Imports	**Trend scenario Exports**
Natural resources and construction	11%	11%
Manufacturing	64	47
Services	25	43
Total (percent)	100	100
Total ($ billions)	$980	$980

How To Read This Table: Under the Caesar scenario for trade patterns in the year 2005, imports and exports each total $980 billion. Of these totals, 16 percent of imports and 14 percent of exports are attributable to natural resource and construction industries (see text for more detail).

NOTE: All values calculated in 1980 dollars. Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1987, based on data from the U.S. Department of Commerce, Bureau of Economic Analysis, and the U.S. Department of Labor, Bureau of Labor Statistics.

Table 8-7b.—1.5 Percent Growth Trade Scenarios

Sector	Caesar scenario Imports	Caesar scenario Exports
Natural resources and construction	16%	14%
Manufacturing	49	51
Services	35	35
Total (percent)	100	100
Total ($ billions)	$710	$710
	Banana scenario Imports	**Banana scenario Exports**
Natural resources and construction	10%	16%
Manufacturing	55	49
Services	35	35
Total (percent)	100	100
Total ($ billions)	$710	$710
	Drucker scenario Imports	**Drucker scenario Exports**
Natural resources and construction	18%	6%
Manufacturing	50	41
Services	32	52
Total (percent)	100	100
Total ($ billions)	$370	$370
	Trend scenario Imports	**Trend scenario Exports**
Natural resources and construction	11%	11%
Manufacturing	64	47
Services	25	43
Total (percent)	100	100
Total ($ billions)	$710	$710

How To Read This Table: Under the Caesar scenario for trade patterns in the year 2005, imports and exports each total $710 billion. Of these totals, 16 percent of imports and 14 percent of exports are attributable to natural resource and construction industries (see text for more detail).

NOTE: All values calculated in 1980 dollars. Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1987, based on data from the U.S. Department of Commerce, Bureau of Economic Analysis, and the U.S. Department of Labor, Bureau of Labor Statistics.

1. The first scenario, called "Caesar" assumes that U.S. exports of manufactured goods and natural resource products grow rapidly, balanced by growing imports of a variety of goods and services. The scenario assumes that trade continues to grow somewhat faster than GNP, but not as fast as it has in recent years. Under the admittedly arbitrary assumptions of this scenario, total trade would increase 150 percent—reaching 30 percent of GNP by 2005. There would be a threefold increase in exports while imports more than double. If the 1974-84 trends continued for the next 20 years, trade would reach 50 percent of GNP.

   Exports of natural resource-based products are assumed to rise sharply to help finance imports of raw materials, of which oil is the largest. The division of trade among the three broad groups —natural resources and construction, manufacturing, and services—is patterned after the relationship that held in 1967. These broad groups are then broken down into the individual industries using the 1972 composition of trade. Both traditional U.S. manufacturing concerns and U.S. high-technology firms fared well in international trade during 1972.
2. The second scenario, "Banana," also envisages a high level of world trade but differs from the first in the composition of U.S. trade. Instead of achieving a balance in manufacturing trade, as in the first scenario, it is assumed that manufacturing trade experiences deficits in high-technology products and gains in comparatively low-wage areas. In addition, there is a large increase in exports of natural resources. The share of trade held by services is retained at the same level as in the Caesar case.

   This scenario is an attempt to extrapolate from recent (1977 to 1984) changes in comparative advantage while bringing trade into balance. This scenario plays down the likely effects on trade of the gradual depletion of U.S. petroleum reserves, and of the substitution of advanced (man-made) for traditional materials in many manufacturing processes.
3. A third scenario, named Drucker since Peter Drucker has recently written on the subject,[28] assumes that technological advances in manufacturing processes will lead to a relative decline in global merchandise trade, leaving the trade of ideas and design embodied in services as the prominent focus. This scenario envisages a situation where competition hinges on an ability to tailor products to small local markets, making it increasingly important to manufacture products near their final consumers. Although there is still substantial trade in manufactured goods, countries are linked primarily by trade in services in this scenario.

   Advanced communications would allow a network of small-scale production facilities to be managed from a central office located virtually anywhere in the world. Advanced materials and processes would offer such a variety of material substitutions that it would be possible to displace some imported materials. This could be true for energy inputs as well, given high levels of energy efficiency and a variety of resources available for producing electricity and liquid fuels.

   Under this scenario, the absolute level of trade would barely increase over current levels (in the 1.5 percent growth case it would decline). It is assumed in the 3 percent growth case that total trade in natural resource products would be less in 2005 than it is now, as technology would lead to greater food self-sufficiency around the world and to reduced oil imports. Trade in manufactured goods is also assumed to be lower than is currently the case, as the decentralization of manufacturing would lead to increased production of tailored products for local markets. On the other hand, trade in services would increase sharply for reasons given above; the balance in services would finance the deficits in trade in manufacturing.
4. The last scenario, "Trend," provides a benchmark for comparing the effects of the other scenarios. Using the same level of trade (30 percent) as Caesar and Banana, Trend uses the 1984 composition of trade, which has been forced to be in balance by scaling down imports. Trade in natural resource products is almost in balance in this scenario. A huge surplus in services is required to balance the deficit in manufacturing.

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[28] Peter Drucker, "The Changed World Economy," *Foreign Affairs*, vol 64, No. 4, spring 1986, pp. 68-79.

Chapter 9

The Composition of Trade

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Chapter 9

The Composition of Trade

Many of the changes occurring in U.S. trade can only be understood by examining specific sectors. Themes developed in earlier chapters, such as the rapid diffusion of information technologies, the increased importance placed on flexibility and adaptability, and the higher degree of interfirm linkage, also apply in an international context—but unlike the discussions of networks in chapters 3 and 6, the present chapter is limited to a brief analysis of production sectors heavily involved in international trade. These include:

- semiconductors,
- drugs and medical supplies,
- autos,
- textiles and apparel,
- machine tools,
- agriculture,
- energy,
- construction,
- business services, and
- computer software.

Among other things, the discussion covers the "export" portion of final demand (see figure 1-4 of ch. 1).

MANUFACTURING

High-Technology Trade

The variety of existing definitions of "technology intensive" has led to confusion and contradictory results in analyses of the position of U.S. producers in export markets. Part of the dilemma involves the curious combination of processes associated with the high-technology industry. "High technology" can range from advanced research and development facilities, product development, or marketing to relatively primitive manufacturing operations. Indeed, assembly of the most sophisticated computer or telecommunications device may involve a production process virtually identical to the one traditionally used to produce garments, and skill levels of the employees involved are often roughly equivalent.[1] Therefore, while part of the enterprise may draw an advantage from an ability to use technology effectively, part of the work may depend on the availability of inexpensive labor.

Much of the production of high-technology goods has become a global operation, with components shipped to a variety of different countries before final assembly—leaving a complex trail of value-added around the world. Moreover, different countries have established very different strategies for producing high-technology goods. For example, U.S. producers have taken advantage of low-wage foreign assembly of semiconductors: in 1983, nearly 80 percent of U.S. circuits were assembled abroad. The Japanese, however, have kept manufacturing close to their design facilities, and assemble 90 percent of their circuits at home.[2] The complexity of this situation makes it difficult to assess accurately differences in national comparative advantage.

Decisions about whether or not to produce a technology-intensive product in the United States depend on complex factors, few of which are easy to include in an assessment of comparative advantage. While some high-technology products (such as generic drugs or semiconductor memory chips) lend themselves to economies of scale and mass production, others (such as application-specific semiconductors and private branch exchange (PBX) systems) require close contact and coordination with a customer. Furthermore, many high-technology goods (particularly pharmaceuticals) are produced offshore to avoid U.S. regulations or trade restrictions.

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[1] M. Fernandez-Kelly, *For We Are Sold, I and My People: Women and Industry in Mexico's Frontier* (Albany, NY: State University Press, 1983). See p. 310 for definitions of "high technology."

[2] Charles Ferguson, "American Microelectronics in Decline: Evidence, Analysis and Alternatives," paper prepared at the Massachusetts Institute of Technology, Cambridge, MA, November 1985.

The United States still commands a much larger share of world technology-intensive exports than any other nation. The Organization for Economic Cooperation and Development (OECD) estimated that in 1982, only three countries—Japan, Britain, and the United States—had an overall comparative advantage in "high R&D intensive industries" (aerospace, office machines, electronics and components, drugs, instruments, and electrical machinery); and only four—the United States, Japan, Germany, and Canada—in "medium R&D intensive industries" (autos, chemicals, non-electrical machinery, rubber & plastics, and non-ferrous metals).

However, the United States lost market share in all products except computers and consumer electronics between 1970 and 1980. Of the 10 high-technology products considered,[3] the United States lost market share in 8 while Japan gained in 10. The overall pattern is striking: U.S. losses are almost perfectly mirrored by Japanese gains.

Between 1965 and 1982, U.S. exports of ten broad product categories[4] grew only slightly more slowly than those of all of the other large suppliers (the 14 largest OECD countries), with the exception of Japan. Japan's high-technology exports grew by an average of 21.9 percent per year during this period, compared to 15.5 percent for the United States and 16.1 percent for all other countries taken as a group.[5] Since 1965, Japan's share of all high-technology exports has more than doubled, from 7.2 percent in 1965 to 17.3 percent in 1982.

By the OECD's measure, however, the "erosion" of U.S. comparative advantage in these industries has been slight. In the high R&D intensive industries, the comparative advantage of three countries—the United Kingdom, France, and Japan—increased during 1970-83; Japan also "shed" its advantage in low R&D intensive industries most rapidly. The comparative advantage of the Netherlands, Sweden, and particularly Germany increased in the medium R&D intensive category.

An examination of imports (see table 9-1), however, reveals strikingly different patterns. Japanese import penetration, low in all areas of manufacturing, increased only slightly during 1970-80. At the beginning of the period imports were low in the United States, as in Japan. But import penetration increased rapidly in the United States. Between 1974 and 1981, U.S. high-technology imports grew nearly twice as fast as output for domestic consumption.[6]

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[3] U.S. Department of Commerce, "An Assessment of U.S. Competitiveness in High Technology Industries," Washington, DC, 1983, pp. 44-45. The product groups considered are drugs & medicines, business machines & equipment, computers, electrical and electronic machines & equipment, telecommunications equipment, electronic components, consumer electronics, jet engines, aircraft, and scientific instruments.

[4] Guided missiles; communications equipment and electronic components; aircraft & parts; office, computing, & accounting machines; ordnance; drugs & medicines; industrial organic chemicals; scientific instruments; engines, turbines & parts; and plastic materials, synthetic resins, rubber & fibers.

[5] Victoria Hatter, "U.S. High Technology Trade and Competitiveness," Office of Trade and Investment Analysis, International Trade Administration, U.S. Department of Commerce, Washington, DC, 1985.

[6] Lester Davis, "New Definition of 'High Tech' Reveals That U.S. Competitiveness in This Area Has Been Declining," *Business America*, vol. 5, No. 2, Oct. 18, 1982.

Table 9-1.—Rates of Import Penetration for Manufacturing: International Comparisons

	High R&D-intensive industries			Medium R&D-intensive industries			Low R&D-intensive industries		
Country	1970	1975	1980	1970	1975	1980	1970	1975	1980
United States	4.8	7.7	14.3	7.0	8.9	11.2	4.8	5.7	6.1
Japan	6.6	6.4	7.9	5.5	5.0	6.9	3.5	4.4	5.4
Germany	21.6	28.4	42.5	22.8	27.4	33.4	16.8	21.6	27.4
France	23.1	23.3	28.8	23.7	26.0	31.6	11.8	14.7	17.7
United Kingdom	18.6	31.2	44.2	22.0	29.3	43.1	13.4	17.4	18.4
Italy	18.3	25.3	33.4	23.8	27.7	41.8	11.9	17.8	25.4
Canada	42.6	45.7	58.0	58.5	59.2	59.2	12.7	14.1	13.8
Australia	42.2	39.7	43.1	30.6	30.4	32.5	14.2	14.8	18.5
Netherlands	71.0	67.8	69.8	80.5	79.3	85.6	38.3	43.4	51.0
Sweden	44.9	46.1	54.6	44.4	48.1	53.5	23.1	27.2	28.3
Belgium	75.7	87.3	N.A.	88.0	86.3	N.A.	40.3	48.8	64.0

NA = Not available.

SOURCE: Organization for Economic Cooperation and Development, *OECD Science and Technology Indicators II: Resources Devoted to R&D, Technological Performance and Industrial Competitiveness* and *Annex*, 1985.

Japanese high-technology imports from the United States have, however, also grown rapidly in the past few years, increasing 42 percent during 1982-86.[7]

Japanese trade in semiconductors is shown in table 9-2. While the Japanese share of both U.S. and world markets grew substantially during 1982-85, more than 90 percent of Japanese demand for these products was met by Japanese suppliers at a higher-than-market price. Indeed, many of the Japanese firms that produce semiconductors (Hitachi, Toshiba, Fujitsu, and NEC) were also major consumers of these devices, and the higher costs were absorbed because management was willing to undertake a long-term development program.[8]

Another analysis of U.S. performance indicates that since 1962 the U.S. world market share has declined in 10 out of 17 technology-intensive sectors, though in four of them—telecommunications apparatus, medicinal & pharmaceutical products, scientific, medical & controlling instruments, and plastics—shares seem to have stabilized or improved slightly between 1977 and 1982.[9] While its international trading position in aircraft has declined, the United States still holds a commanding 45 percent of the world market. Market share in 2 of these 10 products—office machines and photographic supplies—has declined only slightly.

A set of case studies suggests that U.S. firms continue to perform relatively poorly in areas such as semiconductor memory chips, telephone hand-sets, and generic drugs, where comparative advantage depends primarily on price, while the Nation continues to do well in areas such as application-specific semiconductors, advanced telecommunication systems, and biotechnologies—all of which require careful coordination with the consumer. The characteristics of these specialized markets often require that production facilities be located close to customers because it is necessary to adapt new products to shifting consumer needs.

The extent to which this U.S. advantage could be challenged by skillful foreign producers is largely unknown. There is reason to believe that markets for specialty products will increase as both industrial and individual customers begin to appreciate the flexibility inherent in new production technology. This would seem to benefit U.S. producers. On the other hand, the Japanese have proven successful at entering specialty markets and exploiting flexible chip production systems. They have, for example, established 25 to 50 design centers for semiconductors around the world.[10] Relatively standardized products can be made at a central location and adapted through software or site assembly to fit a variety of different applications. Both of these effects would appear to work to the disadvantage of U.S. firms incapable of competing in the production of the basic good. Some of the value-added would, of course, still remain in the United States, although not necessarily in the hands of a U.S.-owned firm.

Semiconductors

The dramatic reversal of the U.S. role in the open market for "merchant" semiconductor manufacturing is symptomatic of the problems the United States is facing.[11] The United States is in grave danger of

Table 9-2.—Japanese Semiconductor Market Shares by Region

Year	North America	Western Europe	Japan	Rest of world	Total
1982	11	7	90	31	33
1983	13	8	91	33	37
1984	16	10	91	34	38
1985	18	11	92	35	40

SOURCE: Charles Ferguson, "American Microelectronics in Decline: Evidence, Analysis, and Alternatives," Massachusetts Institute of Technology, Cambridge, MA, November 1985; based on data from Smith Barney, Dataquest, Semiconductor Industry Association, and *The New York Times.*

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[7] William Finan, Perry Quick, and Karen Sandberg, "The U.S. Trade Position in High Technology: 1980-1986," report prepared for the U.S. Congress, Joint Economic Committee, Washington, DC, October 1986, pp. 10-12.

[8] C. Ferguson, op. cit., footnote 2.

[9] Michael Aho and Howard Rosen, "Trends in Technology Intensive Trade: With Special Reference to U.S. Competitiveness," Bureau of International Labor Affairs, U.S. Department of Labor, 1980; and United Nations, *Statistical Yearbook: 1982*, New York, NY, 1984.

[10] C. Ferguson, op. cit., footnote 2.

[11] See further discussion of competitiveness in this and other industries in N. Bruce Hannay, "Technology and Trade: A Study of U.S. Competitiveness in Seven Industries," in R. Landau and N. Rosenburg, *The Positive Sum Strategy* (Washington, DC: National Academy Press, 1986).

losing its leadership in both the design and the production of semiconductors sold on the open market. On the other hand, the sharp decline in the labor content of semiconductors, and the increasing need to tailor semiconductors and products associated with them to specific markets, seems to indicate that competitive position in this area will increasingly depend on skills in managing and marketing technology rather than on low wages.

Loss of U.S. leadership may be partly due to changes in the structure of the industry: where relatively small, entrepreneurial firms funded by venture capital used to enjoy profitable operations in well-defined market niches, the industry now requires the management skills, capital resources, and patience of a major firm. Major Japanese firms entering the semiconductor business were able to provide such resources, while small U.S. firms had difficulty expanding.

Both the development and production costs of semiconductors have grown explosively. The 32-bit microprocessor chips now entering the market will sell for as little as $100, but are as powerful as the large mainframe computers operating a decade ago. Their development was a major undertaking, requiring a complex network of computer-assisted design and simulation equipment that cost at least $50 million. A semiconductor manufacturing facility could be purchased for $2 million in 1975, while a state-of-the art facility for producing a "very large-scale" integrated semiconductor device today may cost up to $200 million. Components of the manufacturing process have themselves become extraordinarily complex and expensive. Masking units that cost $2 million for the semiconductors of the late 1970s cost $15 million for 256k-chip production in the mid 1980s. Optical systems that once cost up to $300,000 have been replaced by computer-driven electron-beam devices capable of sub-micron resolution costing $3 to $4 million.

The severe reduction in world demand for semiconductors in 1985 (sales were down by 18 percent) increased the problems of U.S. producers. Large Japanese firms maintained market share while U.S. producers suffered 25 to 60 percent losses.[12] Many smaller firms were forced to sell technology to competitors, including the Japanese.

Various factors have been responsible for the emergence of the Japanese semiconductor industry:

- a capacity for effective reverse engineering;
- a management system capable of coordinating large, expensive, and technologically sophisticated development and production operations;
- a strong focus on specialized, high-volume products; and
- a national program that successfully blocked imports during a critical period of the industry's development.

The dramatic progress of Japanese skills in this area is highlighted in table 9-3. The Japanese captured only a small share of the semiconductor market in the 1970s, but dominated semiconductor production by the 1980s.

The Japanese have also begun to challenge U.S. producers in the initial design of advanced memory units, and even of the more sophisticated microprocessor units. In what may be a classic case, Hitachi has become Motorola's second source producer of its MC68000 chip. And using an improved semiconductor technology (CMOS), Motorola is now a second source producer for Hitachi's chip. The large Japanese firms are also challenging U.S. producers in the development of the 32-bit processors that represent today's state of the art. The Japanese are expected to have a virtual world monopoly on one-million bit memory units available in open markets (IBM and AT&T have proprietary designs not sold on the open market, in part because of antitrust considerations).

The strategy giving the Japanese this lead has also propelled them into a leading position in equipment

Table 9-3.—Japanese Share of World Markets in Random Access Semiconductor Memories

	Integration level (thousands of bits/chip)	Japanese share of world markets (percent)
1970	1	0
1974	4	5
1978	16	40
1982	64	70
1985	256	85
1987 (est.) . . .	1,000	90

SOURCE: Charles Ferguson, "American Microelectronics in Decline: Evidence, Analysis, and Alternatives," Massachusetts Institute of Technology, Cambridge, MA, November 1985, based on data from Dataquest, Hambrecht & Quist, and the Semiconductor Industry Association.

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[12] C. Ferguson, op. cit., footnote 2.

designed to produce advanced semiconductors. Devices for optical masking at megabit levels are sold by four Japanese companies and one U.S. company, Teradyne, which is struggling to maintain its market position. Three of the Japanese firms are owned by semiconductor producers (Fujitsu, NEC, and Hitachi).

U.S. losses to Japanese producers in these areas were not primarily due to unique Japanese access to materials or labor, but owed much to trade policies, dynamic management, and marketing strategies designed to capture the benefits of economies of scale. The strategy succeeded primarily because of Japanese ability to learn rapidly and continuously, at first through acquisition of U.S. technology in open purchases and reverse engineering and more recently through independent innovation.

Telecommunications

Like semiconductors, telecommunications equipment is a curious amalgam of mass produced, commodity-type products, such as telephone handsets that compete primarily on the basis of price, and highly sophisticated, specialized products requiring close interaction with customers during initial installation and servicing. U.S. producers have virtually abandoned the commodity market to low-wage nations. AT&T ceased domestic production because it could not compete with low-wage production from overseas despite the low labor content of hand-sets.

The shifting value of the dollar, especially in comparison to the yen, may be changing this calculus. Tokyo-based Fujitsu has begun to export celluar car phones, modems, and computer disk drives from its plant in Texas because the labor and overhead rates per hour are lower than those in Nasu, Japan.[13]

U.S. producers continue to enjoy a significant share of domestic business telephone equipment markets, particularly PBX and large telephone-switching equipment. U.S. production of satellite systems, fiberoptics, and other major components of telecommunications systems remains quite competitive, although the Japanese challenge in optical transmission is growing.

A key question is to what extent do advanced telephone and communications systems resemble consumer electronics commodities, and to what extent do they resemble highly specialized, application-specific devices requiring a strong local manufacturing capability? Even advanced telecommunication products may soon be made overseas. The astonishing power of low-cost microprocessors and memory units makes it possible to develop generic products that can be cheaply tailored to meet a variety of purposes. Because of this, there is no guarantee that U.S. producers can continue to enjoy even the specialty end of telecommunications markets.

The U.S. position is heavily influenced by the fact that most large telecommunication systems abroad are owned and operated by governmental or quasi-governmental concerns that discourage foreign purchasing. Japan recently sold half the shares of the Nippon Telephone and Telegraph system to private owners, but foreign purchases have not been large. The United States has elected to open its markets to foreign sales without insisting on the right to sell into other public systems.

Drugs and Medical Devices

U.S. pharmaceutical manufacturers rely on international sales for a significant portion of their income. In 1982, 41 percent of total sales were to foreign countries, compared to 30 percent in 1967. But foreign firms are beginning to encroach on U.S. markets rapidly and U.S. firms are increasingly producing overseas. The position of U.S. firms is threatened in part by a gap in research investment. Japanese and European companies are spending about 11 percent of each sales dollar on research, compared with about 7 percent for U.S. manufacturers.[14]

In a survey of large pharmaceutical firms, interviewees noted that the decision to locate abroad is driven predominantly by the need to reduce innovation costs and gain market shares. In a few cases, manufacturing abroad is required by local import laws that make it impossible to market a drug unless it is produced within that country's borders. Firms also locate outside the United States for tax reasons. Since pharmaceutical plants are highly automated, whether located in the United States or abroad, cheaper labor does not play a large role. An example of the movement abroad is illustrated by the fact that in 1980, two major U.S. drug companies introduced 94 products world-wide—of which only 11 were manufactured in the United States.[15]

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[13] "For First Time, Fujitsu Exports Gear Made in U.S.A.," *Communications Week*, Feb. 15, 1988, p. 34.

[14] Standard and Poor's Industry Surveys, *Health Care*, Sept. 1, 1983.

Foreign trade is also an important source of income for the U.S. medical devices industry. In 1984, exports—which accounted for about 12 percent of industry shipments—exceeded imports by nearly two-thirds. Even so, U.S. trade surpluses have begun to decline. Historically, the United States has a net trading deficit in medical devices with only one of its major trading partners, West Germany. However, in recent years Japan's medical exports to the United States have grown much faster than U.S. exports to Japan, and the United States has now incurred a trade deficit with Japan in this area.[16]

Other Manufacturing

Competition in manufacturing fields outside of "high-technology" sectors (examined here are autos, textiles and apparel, and machine tools) also depends on sophisticated technology, although often in a less visible way. Sophisticated production technology is needed to compete in an economy where energy prices, the value of the dollar, costs of critical materials, and a variety of other factors can change rapidly and unpredictably. The ability to track progress in both products and production processes is becoming a key to survival in fields as diverse as apparel assembly and auto manufacturing.

Autos

The auto industry has been a dominating force in the U.S. economy for more than 50 years. The industry is heavily linked to other parts of the economy. In recent years these links have extended to include advanced electronics and materials, used both in autos produced and in production equipment. In 1960, the United States produced half the world's autos. Today Japan is close to that figure. The United States imported 38 percent of all autos sold in 1986.[17]

Foreign sourcing of auto parts has recently become increasingly common. The suppliers of the imported components or finished vehicles may be partly or fully owned by the importing U.S. manufacturer (see table 9-4), or may be unrelated in terms of equity holdings—a process known as "out-sourcing." Of the

Table 9-4.—Major U.S. and Foreign Equity Holdings in Auto Firms, 1987

U.S. ownership of foreign firms:

American Motors Corp.
49% of Arab American Vehicles Ltd., Egypt
31% of Beijing Automobile Works, China

Chrysler
50% of Diamond-Star Motors Corp., USA with Mitsubishi
24% of Mitsubishi Motors Corp., Japan
16% of Maserati S.P.A.,Italy

Ford Motor Co.
70% of Ford Lio Motor Co., Taiwan
25% of Mazda Motor Corp., Japan
48% of Iveco-Ford Truck Ltd., Great Britain (with Fiat)
10% of Kia Motors Corp., South Korea
42% of South African Motor Corp., South Africa
30% of AMIN Holdings, Malaysia
30% of Otomobile Sanayi Anomin Sirketi, Turkey

General Motors Corp.
50% of Daewoo Motor Co., Ltd, S. Korea
39% of Isuzu Motors Ltd., Japan
24% of Volvo GM Heavy Truck Corp., USA with Volvo
5% of Suzuki Motor Corp., Japan
50% of New United Motor Manufacturing, USA with Toyota
49% of General Motors Kenya Ltd., Kenya
49% of Constructora Venezolana de Vehiculos, Venezuela
46% of Autos y Maquinas del Ecuador
31% of General Motors Egypt S.A.E
22% of Omnibus BB Transportes S.A., Ecuador
20% of Industries Mecaniques Maghrebines S.A., Tunisia

Foreign ownership of U.S. firms:

Japan
Fuji Heavy Industries Ltd.: 49% of Subaru-Isuzu Automotive Inc., USA
Isuzu Motors Corp.: 51% of Subaru-Isuzu Automotive Inc., USA
Mitsubishi Motors Corp.: 50% of Diamond-Star Motors Corp, USA
Toyota Motor Corp.: 50% of New United Motor Manufacturing Inc., USA

Europe
Renault: 42% of Mack Trucks Inc., USA

SOURCE: *Automotive News*, 1987 Market Data Book Issue.

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[15] Results of interviews with executives of several major pharmaceutical firms conducted for the Office of Technology Assessment by the Conservation for Human Resources, Columbia University, New York, NY.

[16] U.S. Department of Commerce, Bureau of Industrial Economics, *U.S. Industrial Outlook, 1987* (Washington, DC: U.S. Government Printing Office, 1987).

[17] U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, vol. 67, No. 6, July 1987, Table 1.17.

big three, Chrysler is the leading out-sourcer. In terms of value, about 70 percent of the components of Chrysler's vehicles are manufactured by outside suppliers.[18] Auto makers also supply their U.S. auto assembly plants with components produced by their own foreign plants. In addition, each of the big three imports at least one foreign-made vehicle and resells it under a domestic brand name.

Experiences are mixed. Some changes (such as lighter materials and electronic controls) have been introduced, but more innovation is needed. A comparison with the Japanese auto industry suggests that more changes in organization, management, and labor relations will be required.[19] U.S. firms have taken major steps to restructure domestic production, and have entered joint ownership arrangements with Japanese firms.

Textiles and Apparel[20]

Textiles and apparel imports have risen sharply, leading to a 1986 deficit of over $21 billion. This is 4.5 times higher than the 1980 deficit (in current dollars). Trade growth was particularly rapid in areas where a significant amount of hand labor is required (a significant part of the apparel market) while U.S. producers maintained share in areas where highly automated processes keep labor costs low.

The introduction of a "quick response" system, which holds inventories low and avoids overstocking, could do much to help U.S. producers compete with low-wage nations simply by virtue of significantly reduced inventories. However, this will require major changes in how information flows between the different components in the production and retail chain.

Virtually all textile production technology is currently being imported, and producers of textile machinery and apparel assembly machinery conduct virtually no research. U.S. textile machinery manufacturers that dominated the global market for looms in 1960 now make *none* of the widely used, advanced programmable/shuttleless looms that can increase output by 200 to 300 percent. In 1983, more than 90 percent of U.S. textile equipment production was of replacement parts for old U.S.-made looms.

The single major investment in advanced apparel production in the past decade involved a joint project between industry, labor, and the U.S. Government. The project, known as the Textile/Clothing Technology Corporation (TC)^2, spearheads the U.S. effort in automated sewing. Thus far, it has succeeded in automating the production of sleeves for men's suits. Industry and organized labor are providing approximately $5 million a year for these and related efforts, and the Federal Government has pledged $3 million. This amount could be much greater; Japan is spending $80 million to develop a fully automated apparel process for the 21st century. While TC^2 is an effort to automate sewing production, the Japanese effort is state-led industrial restructuring on a large scale.

Machine Tools

It is somewhat ironic that the basic tools of mass production cannot themselves be mass produced. Of total world machine tool production, 75 percent is produced in relatively small batches, and 85 percent of all batches have fewer than 50 parts.[21] Small batch production and the need for careful integration of the design, installation, and operation of sophisticated machine tool systems would appear to give domestic producers a natural competitive advantage. In fact, foreign producers—particularly those in Japan and West Germany—have made major inroads into U.S. markets. In 1985, the United States imported 41 percent of its machine tools—nearly half from Japan, and about 14 percent from West Germany.

A quota on machine tool imports took effect January 1, 1987. It applied to Japan, Taiwan, West Germany, and Switzerland, limiting their shipments to the United States for 5 years. These temporary restraints were ordered on national security grounds so as to give domestic producers time to modernize. Domestic producers could gain a 20 percent market share from the quota for Japan alone.[22]

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[18] Kevin Flaherty, "Foreign Sourcing by the U.S. Automobile Industry," report prepared for the U.S. Congressional Research Service, Washington, DC, Nov. 8, 1985.

[19] W.J. Hampton and J.R. Norman, "General Motors: What Went Wrong?" Mar. 16, 1987, p. 102.

[20] This section is drawn from U.S. Congress, Office of Technology Assessment, *The U.S. Textile and Apparel Industry: A Revolution in Progress—Special Report*, OTA-TET-332 (Washington, DC: U.S. Government Printing Office, April 1987).

[21] U.S. Department of Commerce, International Trade Administration, "A Competitive Assessment of the U.S. Flexible Manufacturing Systems Industry," July 1985, p. 8.

Since much of the equipment marketed by Japanese firms was developed internally by firms that needed the equipment for their own production, the Japanese enjoy a good international reputation for bringing equipment to a plant that works as advertised and performs comparatively reliably. This gives them a considerable advantage in overcoming producers' reluctance to invest in equipment fraught with many unknowns.

In part because of an overt government program to improve metal fabrication, Japan is the largest producer of machine tools and robots in the world. In 1984, Japan exported more than one-third of the machine tools it made and imported only 3.4 percent of its consumption. Most of the industry's production is relatively small in scale—81 percent of the firms employ fewer than 20 workers. Nonetheless, a growing fraction of the production is moving to South Korea, Singapore, and Taiwan, as well as to licensed manufacturers in the United States, the United Kingdom, West Germany, and Belgium.[23] In 1982, Japanese producers were using about 31,000 robots—virtually all domestically produced, while the United States, with nearly twice as much gross output, used only about 7,000.

In terms of price and performance, U.S. machine tools have a somewhat mixed record in international markets. Imports have gained a solid position in the U.S. market. U.S. and European (West German, Italian, and French in particular) producers enjoy a good reputation in highly sophisticated machine tools designed for specialized applications such as heavy cutting, and in systems that require a considerable amount of software design. U.S. producers of advanced equipment appear to have a strong advantage in the fabrication of military equipment, but much of this equipment is so highly specialized and sophisticated that it does not transfer easily into a cost-conscious commercial market.[24] The Japanese enjoy a reputation for high-quality, small- and medium-sized machining centers that are durable, simple, and flexible.[25]

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[22] *The Washington Post*, Dec. 17, 1986, p. 4.

[23] "A Competitive Assessment of the U.S. Flexible Manufacturing Systems Industry," op. cit., footnote 21, p. 32.

[24] Ibid., p. 81.

[25] Ibid.

NATURAL RESOURCES

While the petroleum crises of 1972/73 and 1979 forced the United States to recognize its dependence on foreign resources, the United States has suffered a trade deficit in raw materials for some time. In 1985, food, raw materials, and fuels constituted 24 percent of U.S. exports and 27 percent of U.S. imports, resulting in a net deficit of $45 billion. But many resource-intensive U.S. industries actually gained ground in comparison with other sectors of the economy.

This occurred partly because many of the Nation's major trading partners are much more poorly endowed with resources. On average, food, raw materials, and energy represented 40 percent of the imports of the seven largest free economies (75 percent of Japan's imports) in 1984, and 20 percent of their exports (2 percent of Japan's exports). Most European nations, and certainly Japan, rely on manufacturing exports to cover large trade deficits in resources.[26] Indeed, it is possible that Japan's enormous trade surplus occurred partly because Japan was positioning itself to pay large fuel import bills—bills that fortuitously did not need to be paid because oil prices fell.

Agriculture

The United States enjoyed enormous growth in net exports of agricultural products during the late 1970s and early 1980s, but the trade surplus has been eroded in recent years. U.S. exports of bulk commodities (primarily wheat, corn, and soybeans) have fallen sharply while imports of high-value products (fruits, vegetables, and meats) continue to increase. Ironically, the United States has never done well in capturing a large fraction of the value of world food trade; rather, the Nation has done well in producing large volumes of commodities. In 1984, the United States had 34 percent of the *volume* of world trade in food and food products but only 13 percent of the *value* of these products. The United States has been a net importer of processed food since 1983.[27]

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[26] Directorate of Intelligence, *Handbook of Economic Statistics, 1986* (Washington, DC: U.S. Government Printing Office, 1986).

The export boom of the late 1970s was driven by a rapid increase in world demand for imported food made possible by economic growth in developing nations, the entry of China into world markets, and continued crop failures in the USSR. U.S. farmers were in a unique position to exploit these developments because they had large stocks in storage and could also expand production rapidly. During the early 1970s, harvested wheat acreage in the United States rose by an amount greater than the total harvested by Canada during that period.[28]

But conditions changed rapidly after 1980. A global recession meant that many developing nations lacked the resources to purchase imported foods. Many nations, particularly in the European Economic Community (EEC), rapidly increased production to enjoy a share of expanding world markets. The rising value of the U.S. dollar helped many nations enter world markets, and once there they were reluctant to abandon their market shares when world demand decreased and the value of the dollar fell. Many maintained shares by providing export subsidies for their farmers. Many developing nations with heavy debt burdens have been encouraged by the World Bank, the International Monetary Fund, and U.S. banks to increase exports of agricultural products in order to earn the foreign currency needed to repay their debts.

Technology transfer played a key role in these events. The U.S. farm community no longer enjoys a clear lead in agricultural technologies, partly because U.S. multinational corporations have successfully marketed new products abroad. Between 1959 and 1980, global expenditures on public agricultural research increased by 360 percent in real terms, and the number of scientists committed to agricultural research tripled. The North American share of this research spending fell from 37 to 23 percent during the period, while research spending in Latin America and Asia increased six-fold. The United States did contribute heavily to the growth in world research capabilities—but nearly 30 percent of all students receiving PhDs in agriculture and home economics in the United States between 1975 and 1979 were foreign, as were more than 43 percent of those who received degrees in agronomy, soils, and soil science.[29]

The rapid equilibration of world agricultural technology has, of course, had enormous benefits. The "Green Revolution" enabled many nations to feed themselves better, reducing demand for imports and eroding the comparative advantage of large U.S. farming regions. Many of the emerging technologies will have a relatively greater influence on the production costs in regions with poor resources than in well-developed regions. While it is difficult to obtain accurate estimates of differences in real production costs around the world, it appears that many basic agricultural commodities can now be produced at a lower cost outside the United States.

It is clear that the U.S. agricultural community, once dominant in feeding the world, will need to work much harder to maintain a trade surplus in the future.

Energy

Petroleum has dominated U.S. resource trade for a decade. Energy imports climbed to one-third of all U.S. imports (half of Japan's imports) in 1981, but have fallen sharply as a result of the collapse of the Organization of Petroleum Exporting Countries (OPEC) cartel, reduced U.S. energy demand, achievements in diversification of energy inputs in the U.S. economy, and significant efforts to find substitutes for petroleum. Should these efforts for finding substitutes for petroleum slacken, however, fuel imports are likely to increase steadily in the future.

U.S. petroleum production is likely to decline 10 to 30 percent by the turn of the century and more sharply after that. The U.S. Department of Energy's

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[27] Penelope Cate, "Upcoming World Trade Talks: What's at Stake for U.S. Agriculture," *Congressional Research Service Review*, vol. 7, No. 8, September 1986, pp. 2-5, 26-27.

[28] U.S. Congress, Office of Technology Assessment, *A Review of U.S. Competitiveness in Agricultural Trade—A Technical Memorandum*, OTA-TM-TET-29 (Washington, DC: U.S. Government Printing Office, October 1986).

[29] Robert E. Evanson, J. Putnam, and Carl Pray, "The Potential for Transfer of U.S. Agricultural Technology," contract report prepared for the Office of Technology Assessment, 1985.

(DOE) "revised reference case" shows indigenous production declining 42 percent between 1985 and 2010.[30] If U.S. energy demand follows the DOE forecast, U.S. imports of petroleum (measured in barrels) will increase 225 percent by 2005 and 240 percent by 2010.

Overall world demand for imported fuels will increase if the DOE forecasts are correct, and demand for oil by developing nations will increase as a result of economic growth and development. World supplies, however, will shrink as output from the fields in the United States, the North Sea, and the Soviet Union begins to decline near the turn of the century. Arab OPEC countries, particularly Saudi Arabia, will then dominate world exports even more than they do currently. It is extremely difficult to forecast the effect of these developments on world prices, but the United States will need to find a way either to pay for substantially rising oil imports during the next 20 years or to reduce demand for petroleum through greater energy efficiency and/or alternative fuels.

Efficiency in automobile travel will be a key issue. Unfortunately, the Japanese and other producers appear better prepared to move highly efficient automobiles (and other energy-efficient products) to the market than U.S. manufacturers. An international event that resulted in a sharp increase in world oil prices would almost certainly leave foreign producers in a better position to meet world demand for efficient vehicles than U.S. firms.

Other Raw Materials

In addition to more efficient use of energy, new technologies could change demand for other kinds of raw materials.[31] New materials are likely to become competitive as substitutes for traditional ferrous and non-ferrous metals. Potentially vulnerable industries include copper, for which fiber optics and superconductors are substitutes; aluminum, for which ceramics and carbon fiber composites might substitute; and steel sheet, which could over time see competition from superpolymers used to produce light corrosion resistant shells for autos, aircraft, and large storage containers.[32]

Material demand will be further reduced by designing products such as automobiles for longer life expectancies, and through recycling. Demand for raw materials such as steel, chemicals, paper, cement, and aluminum represents a shrinking share of the economies of most developed nations.[33]

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[30] U.S. Department of Energy, Office of Policy Planning and Analysis, "National Energy Policy Plan Projections to 2010," Washington, DC, June 1987, table 3-10.

[31] See U.S. Congress, Office of Technology Assessment, *Advanced Materials by Design*, Washington, DC, forthcoming.

[32] Harald Malmgren, "Technological Change and Trade Policy," Trade Department of the Ministry of Foreign Affairs, Sweden, in *New Technologies and World Trade: Proceedings of a Symposium in Stockholm*, Stockholm, Sweden, June 5-6, 1984.

[33] Eric Larson, Marc Ross, and Robert Williams, "Beyond the Era of Materials," *Scientific American*, vol. 254, No. 6, June 1986, p. 34.

CONSTRUCTION

The U.S. construction industry is being integrated rapidly into world markets. U.S. heavy construction firms, and architecture and engineering businesses, have played a major role in world markets since the end of World War II. They now face strong competition, particularly from Asian countries. Even U.S. residential construction firms must now compete with foreign producers, as appliances, building components (ranging from kitchen cabinets to door knobs), hand tools, and even entire housing units are being imported.[34]

Although foreign construction contracts were gained by just 60 of the 400 largest U.S. contractors in 1985 (accounting for 21 percent of total contract awards),[35] the United States stood at the forefront of this expanding world market as recently as 1972. The oil boom of the 1970s increased demand for construction in OPEC countries, which spent substantial sums building highways, ports, and other additions to their infrastructures. While the volume of U.S. exports rose to meet this developing market, the U.S. share of world trade in construction held steady as competing industrial nations also increased their exports.

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[34] U.S. Congress, Office of Technology Assessment, *Technology, Trade, and the U.S. Residential Construction Industry—Special Report*, OTA-TET-315 (Washington, DC: Government Printing Office, September 1986).

[35] U.S. Congress, Office of Technology Assessment, *International Competition in Services*, OTA-ITE-328 (Washington, DC: U.S. Government Printing Office, July 1987), p. 124.

The world market for structures became increasingly competitive in the 1980s. Several factors have contributed to this, including deteriorating economic conditions and the maturation of construction firms in the developing world, penetration of international markets by construction firms from nations such as South Korea and Brazil, and policies of foreign governments to subsidize construction exports.

Moreover, foreign firms have begun to enter the U.S. market. Both the number and the earnings of foreign firms that have been awarded U.S. contracts have grown dramatically. The number of foreign firms with U.S. affiliates has also continued to increase.

TRADE IN SERVICES

The poor U.S. performance in merchandise trade in recent years has been partially offset by trade surpluses in services. Two main components of trade in services can be distinguished: income from foreign investments, and other services covering a wide range of activities such as business services, banking, insurance, construction, consulting, information, and travel.

Data on income from foreign investment are believed to be fairly accurate, but trade in "services" other than factor income is a notoriously difficult field to analyze since much of the value goes unmeasured.[36] According to the official accounts, for example, income from services other than factor income offsets less than 3 percent of the merchandise trade deficit. OTA estimates, however, imply a 16 percent offset (see table 9-5). A trade surplus in construction, consulting, engineering, technology, health, and a menagerie of miscellaneous activities cataloged as services (including income from international organizations in the United States) offset a $7 billion trade deficit in travel and transportation in 1984.

The difficulties encountered in developing international agreements about trade in services are even more complex than those encountered in trade in products. Services can raise issues of national security (nations want control over their own communication system), "cultural pollution" (there is concern about the effects of imported television programming), and different national standards of privacy (compared with some Scandinavian nations, the United States tends to be more concerned about permitting government access to personal information and less concerned about corporate access). The communications and broadcasting industries in many nations are under direct state control. In virtually all nations (the United States being no exception), trade policy in services requires coordination with regulatory agencies in areas like banking, communications, or utilities.

Business Services

The net U.S. trade balance in business services was negligible in 1984. There was a significant trade deficit in the most technologically demanding of these services—telecommunications and data processing—offset by a trade surplus in areas such as banking, insurance, and selling franchises for McDonald's and other firms.

International financial and banking services have grown more than 20 percent per year for the past 20 years, and the United States has been a leader in this field. U.S. financial service firms have been aggressive, innovative, and efficient—qualities that have enabled them to maintain their international position in an increasingly deregulated and competitive global environment.

Innovations in financial service products, and in the technology for delivering services, have helped U.S. banks maintain their ability to compete in international markets.[37] Indeed, U.S. firms have dominated markets for new products and financial services.

Although foreign banks have increased their presence in the United States siginificantly in recent years, the United States still enjoyed a trade surplus of more than $1 billion in banking in 1984. Conflicting local ordinances and long-established national

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[36] U.S. Congress, Office of Technology Assessment, *Trade in Services: Exports and Foreign Revenues—Special Report*, OTA-ITE-316 (Washington, DC: U.S. Government Printing Office, September 1986).

[37] *Trade in Services: Exports and Foreign Revenues—Special Report*, op. cit., footnote 34.

Table 9-5.—Trade in Services, 1984 (billions of dollars)

Industry	(1) Exports	(2) Imports	(1)-(2) Balance
Business services	**$18.9**	**$18.9**	**$0.1**
Accounting	0.4	0.0	0.4
Leasing	0.7	0.5	0.2
Legal	1.0	0.5	0.5
Telecommunications	1.3	2.4	(1.1)
Advertising	0.3	0.0	0.3
Data processing	0.7	2.0	(1.4)
Insurance	8.0	8.6	(0.6)
Investment bank/broker	5.9	4.8	1.1
Franchising	0.7	0.0	0.7
Construction	**5.0**	**1.0**	**4.0**
Consulting/engineering	**2.3**	**1.1**	**1.2**
Management consulting	1.1	0.9	0.2
Engineering	1.2	0.2	1.0
Information/technology	**12.1**	**3.1**	**9.0**
Education	2.2	0.2	2.0
Information	1.6	0.5	1.1
Licensing	5.5	1.0	4.5
Software	2.9	1.4	1.5
Transportation/travel	**32.2**	**39.2**	**(7.0)**
Transportation	18.5	22.8	(4.3)
Travel	13.7	16.4	(2.7)
Other	**9.4**	**3.6**	**5.8**
Health	1.8	0.0	1.8
Motion pictures	1.9	1.5	0.4
Miscellaneous[a]	5.7	2.1	3.6
Total	77.5	65.7	11.8

[a] Affiliated and unaffiliated fees (excluding royalties and license fees included under "licensing"), expenditures in the U.S. by foreign governments and international organizations, receipts from Canadian affiliate trade unions, miscellaneous commissions, wages of U.S. residents abroad, spending by temporary resident aliens, and other private miscellaneous services.

NOTE: Values given are rounded mid-points ( ) = Negative.

SOURCE: U.S. Congress, Office of Technology Assessment, *Trade in Services: Exports and Foreign Revenues—Special Report*, OTA-ITE-316 (Washington, DC: U.S. Government Printing Office, September 1986).

traditions of doing business typically make it more difficult for a foreign firm to provide useful banking services than to sell a manufactured product. For example, U.S. banking laws greatly limit banks with branches in different States and prevent many kinds of direct industrial financing.[38]

There seems to be only one potential threat to the U.S. rank as leader of the financial services industry: Japan. Japanese banks now hold more international deposits than their U.S. counterparts: 26 percent of the total at the beginning of 1986, compared to 24 percent for U.S. banks.

Citicorp used to be the world's largest bank, but of the top 50 current banking concerns in the world, 18 are Japanese, 16 are European, and only 9 are American. In March of 1985, eight of the top ten banks were Japanese, and Citicorp was fifth.[39] Six of the ten largest banks in California were foreign-owned in 1984, up from two in 1979.[40]

The vast accumulation of wealth in traditional U.S. insurance firms gives them potentially great power in overseas markets. The largest five insurers in the world—Prudential, Metropolitan, Aetna, Equitable, and Cigna—and 14 of the largest 25, are American. Of the rest, five are Japanese and six are European.[41] However, U.S. insurance companies have been protected at home from competition with other financial institutions, and may therefore not be able to compete effectively for insurance business in foreign markets.

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[38] See Stephen Cohen and John Zysman, *Manufacturing Matters: The Myth of a Post-Industrial Economy* (New York, NY: Basic Books, 1987).

[39] Worldscope, Wright Investor's Service and Center for International Financial Analysis & Research, 1986, reported in *The Wall Street Journal*, European edition, Oct. 6, 1986.

[40] *San Francisco Chronicle*, July 20, 1984, p. 37.

[41] Worldscope, op. cit., footnote 39.

Because business services need to be carefully tailored to the needs of individual clients, they typically require close association with the firm being serviced. Advanced telecommunications systems may permit closer working relationships with clients abroad, but it is not yet apparent that these links will be able to substitute for the close personal relationships required for many legal, accounting, and other service functions. As a result, jobs in transactional services like banking and business services tend to be susceptible to the indirect effects of trade in other sectors, particulary manufacturing (see ch. 7 and table 7-10).

Software[42]

The computing capability of all information systems depends on software, which has the qualities of both a service and a product. While computer hardware manufacturers continue to develop a large amount of software, a rapidly growing software industry has also emerged. The U.S. software industry is the largest in the world, and is also the world's largest exporter. In 1985, U.S. firms controlled about 70 percent of the world software market and earned some $21 billion. Foreign sales totaled $4 billion. The largest portion of these revenues came from the sale of operating systems and applications software for large, mainframe computers. With few exceptions, foreign firms lag well behind U.S. firms in software technology as well as in sales.

Although U.S.-based firms have been market leaders for some time and will continue to be highly competitive, their share of the world market seems destined to shrink somewhat in coming years. Foreign software firms will improve their relative positions, particularly as they follow the U.S. lead in switching to packaged (as opposed to customized) software. While European firms—led by France, which has the second most competitive software industry after the United States—have been quite visible internationally, over the long run Japan is likely to emerge as the major U.S. competitor in software. Japanese government and industry have made major commitments to improve software productivity and to create new generations of software technology.

U.S. leadership in the industry resulted from its domestic market—by far the largest in the world. With the interdependence of hardware and software design growing stronger, this should prove a continuing source of strength for the U.S. industry. Other traditional sources of strength in the U.S. industry are a large number of skilled personnel, strong R&D programs with substantial Federal funding, and strong and flexible U.S. capital markets. U.S. Government policies that ensure access to foreign markets can help maintain existing U.S. advantages in this industry. The future strength of the U.S. industry, however, depends most critically on its ability to master fourth generation languages, on artificial intelligence, and on progress in automating the production of software.

Income From Technology

The United States appears to be doing well in the sale of technology. In 1984, the United States enjoyed a $9 billion trade surplus in sales of information of all kinds: educational services (foreign students overwhelmingly choose technical subjects), royalties, licenses, and information (again see table 9-5). Licensing alone earned $4.5 billion in 1984.

Income from technology transfer has shown steady growth over the past decade. Most U.S. revenues from royalties and fees (76 percent) came from developed countries, with Japan's portion rising from 3 percent in 1967 to 7 percent in 1981.[43] Large U.S. firms appear to prefer transferring technology to subsidiaries through joint ventures, rather than licensing to independent firms. The desire to avoid licensing varies, however, according to the age of the technology, the size of the licensor, and the importance of the market to which the technology is licensed.

U.S. receipts from education were also positive. A growing fraction of the science and engineering students in the United States are foreign. In 1981, 23 percent of all graduate science and engineering students, and 43 percent of all engineering students, were foreign.[44]

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[42] This section is drawn largely from *International Competition in Services*, op. cit., footnote 35.

[43] Meryl L. Kroner, "U.S. International Transactions in Royalties and Fees, 1967-78," *Survey of Current Business*, January 1980, p. 25; and U.S. Department of Commerce, unpublished tables; cited in National Science Foundation, *Science Indicators 1982*, Washington, DC, 1982.

[44] *Science Indicators 1982*, op. cit., footnote 43, p. 122.

The positive U.S. performance in technology trade is mirrored in the negative "technology balances" of the Nation's major trading partners. Both West Germany and Japan have been aggressive importers of foreign technology, as have Spain, Italy, and the Netherlands. This pattern is reflected in the positive, though shrinking, balance of patents granted to U.S. firms and individuals, and foreign nationals.

The statistics cited above, however, provide an extremely poor and possibly misleading measure of the value of technology flowing across national borders.[45] Information flows within a firm's divisions or within subsidiaries of multinational firms are notoriously difficult to measure, though it is estimated that 40 percent of all U.S. trade may be intrafirm.[46] Conversely, it is not clear that subsidiaries of foreign firms operating in the United States transfer significant amounts of technology to the United States. There is ample anecdotal evidence to suggest that Japanese automobile firms (such as the Toyota-GM venture) keep the most technologically sophisticated parts of their operations at home, sending only the relatively low-technology assembly operations to the United States.

On the other hand, the Japanese partners in Boeing's 767 aircraft venture participated precisely because they hoped to use the experience to learn things about aircraft production that either were not for sale or could not be sold because they involved complex, hands-on "know how." NEC has learned enough about computers from foreign partnerships to attract a partnership with Honeywell, in which NEC and the Bull company will develop and produce computers and Honeywell will primarily provide marketing services. Komatsu learned an enormous amount about diesel engines from Cummins Engines. In no case does it appear that the U.S. partner learned significantly from its foreign partner.[47]

Perhaps more importantly, there are compelling reasons to believe that the real value of a technology cannot be fairly reflected in its price, since the buyer cannot know its full value in advance. Frequently, a technology purchased for one purpose turns out to have its greatest potential in an entirely unexpected area (the technology for the "compact disk" system, for example, was not purchased with sound reproduction in mind). The social value (or the social cost) of the innovation is very different from the value a firm can place on a technology in the open market.[48]

In addition, enormous amounts of technology are transferred embedded in equipment. Proprietary technologies and associated end-products are frequently introduced abroad through a subsidiary, joint venture, or licensing agreement. These technology transfers account for an important component of the return to U.S. firms on R&D done in the United States and thus constitute an additional incentive to R&D expenditure. One survey has found that 30 percent of the returns from 30 major firms' R&D was expected to come from foreign sales or foreign utilization.[49]

While the trade surplus in information could be taken to demonstrate the continued technological dominance of the United States, it may also show a greater willingness and ability on the part of foreign governments and firms to scan world markets actively for new technology. The potential loss in U.S. competitiveness resulting from this trade surplus in technology sales may well outweigh the immediate income generated from the sales. The reluctance, or inability, of U.S. firms to purchase technology from abroad may be due to various factors, ranging from corporate cultures that have grown up with the assumption that foreign technologies are inferior, to policies on the part of foreign governments that hamper the outflow of technological knowledge. In any event, it is not yet clear whether the trade surplus in "information" services should be considered an asset or a liability.

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[45] Raymond Vernon, "Technology Transfer Between the U.S. and other Industrialized Countries," paper prepared for the Office of Technology Assessment, Mar. 13, 1984.

[46] John Hein, "What the Trade Numbers Hide," *Across the Board*, vol. XXIV, No. 10, October 1987, pp. 12-13; and James S. Little, "Intra-Firm Trade: An Update," *New England Economic Review*, May-June 1987, pp. 46-51.

[47] Yves Doz, Gary Hamel, and C.K. Prahalad, "International Strategic Partnerships—Success or Surrender?" paper delivered to the Strategic Management Society, Singapore, 1986.

[48] A detailed study of 17 industrial innovations found that their social rate of return was more than double the before-tax private rate of return. See E. Mansfield and A. Romeo, "Technology Transfer to Overseas Subsidiaries of U.S.-based Firms," *Quarterly Journal of Economics*, vol. 95, 1980, pp. 737-750. By definition, high-technology industries are R&D intensive. Even so, the concentration of private industrial R&D in these sectors is surprising. The Department of Commerce found, for example, that only 10 R&D-intensive industries accounted for more than 60 percent of total private industrial R&D, although they represented only 13 percent of the value of manufacturing product shipments; see "An Assessment of U.S. Competitiveness in High Technology Industries," op. cit., footnote 3.

[49] Ibid.

It is widely agreed that the production of knowledge is an area in which the difficulty of securing property rights induces market failure, with the result that there may be inadequate research in areas where property rights cannot be exercised and excessive research in areas where they can.[50] Given the already rapid diffusion of the technologies discussed above, the counterfeiting of trademarked commercial merchandise and the theft and duplication of intellectual property have become major international issues. There have been extensive efforts to achieve multilateral agreements in this area,[51] but so far progress has been disappointing. Political pressure is building for bilateral action. The United States has already pressured Hong Kong, Taiwan, Singapore, and South Korea to clamp down on offenders on the grounds that without adequate protection, new investors might be reluctant to establish themselves abroad and to transfer technology.

Existing agreements involving intellectual property rights administered under the World Intellectual Property Organization (WIPO) are less than adequate. They build on principles of national treatment, but statutes vary significantly from country to country and enforcement is usually weak or non-existent. Provisions for the settlement of international disputes are lacking. Additional problems are created by the nature of technological change itself.

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[50] For more on this subject, see U.S. Congress, Office of Technology Assessment, *Intellectual Property Rights in an Age of Electronics and Information*, OTA-CIT-302 (Washington, DC: U.S. Government Printing Office, April 1986).

[51] In 1979, the United States and the European Economic Community (EEC) reached agreement (ad referendum) on the text of a code to deter international trade in counterfeited trademarked merchandise. Over the next 2 years, the United States and the EEC intensified efforts to broaden participation in the code, resulting in multilateral discussions with a number of GATT countries, including Canada and Japan. These talks resulted in a revised text to be used as the basis for negotiation of a code acceptable to all GATT members. While the agreement was accepted by the four major countries, the counterfeit code was shelved at the 1982 GATT ministerial meeting. Some less developed countries opposed any mention of the issue in the GATT, arguing that it fell under purview of the World Intellectual Property Organization (WIPO) rather than the GATT. Though the Ministerial meeting directed the Director-General of the GATT to hold consultations with WIPO, little progress has been recorded to date.

Part IV

People in the Production Recipe

The following three chapters look inside the "value-added" generated by businesses and business networks to see how structural change in the U.S. economy is transforming the nature of work. Networks measured earlier in terms of flows of money can also be described as networks of people contributing time, skill, dedication, compassion, and inspiration. The kinds of human contributions needed to provide an amenity like Housing, Transportation, or Health are changing even more rapidly than the shares of different business sectors described in chapter 5. Trends measured in these areas are difficult to interpret, since there appears to be an enormous range of choice in the kinds of jobs created by production systems using emerging technology.

As was the case in Part II, there is no good vocabulary for describing many of the changes taking place. Structural change must be measured in several different ways: the share of all occupations held by different occupations; the scale and scope of working teams; the way such teams are managed formally and informally.

Many traditional occupations (i.e., machine operators, farmers, and data entry clerks) are declining while jobs are growing rapidly in areas lacking clear definition. Out of desperation, new jobs are often called things like "para-professionals," "para-librarians," or "super-clerks."

For many, the most critical skill has become an ability to keep abreast of change, to determine what needs to be learned, and learn while performing the work that needs to be done. The most important attribute of formal training may be the extent to which it creates a capacity for functioning effectively in ambiguous situations. While modern technology may theoretically permit a production system to operate efficiently with a small, elite group of managers controlling large groups of employees, whose tasks have been reduced to mindless repetition monitored by computers, such an approach seems unlikely to be compatible with the need to tailor products and react quickly to changing conditions.

When an insurance clerk must adapt to a new computer terminal, for example, he or she is forced to learn both a new keyboard and new underwriting software—in effect, learning a new job in the process. A nurse heading a ward must keep books in a different way, in order to satisfy changed public regulations and the expectations of newly cost-conscious hospital management. A cutter in an apparel factory now learns how to use laser cutters instead of those based on knives, and must become an alert member of a "quick response" team—spending a considerable amount of time in brief meetings to establish schedules for rapidly shifting production requirements, rather than working in isolation with a rigidly prescribed schedule.

In an odd way, changing production strategies and new technologies may make disparate jobs more similar. Farm managers, operators of nuclear power plants, insurance salesmen, and teachers all spend an increasing amount of time wrestling with abstractions in front of terminals. Jobs with high degrees of independence, such as independent physicians, teachers, and independent home builders, are now being integrated into networks—though not necessarily into hierarchical structures. Jobs once part of hierarchies may be given greater independence.

A large fraction of new jobs require the capacity for working with other people. Operation of production networks capable of delivering specialized products rapidly to markets depend increasingly on groups of people working effectively as a team. The teams may last for many years, or may be assembled on a temporary basis for a specific purpose. The performance of such teams often depends as much on the social skills of their participants as on formal training or experience.

Members of complex production networks often have never met one another. Few of them actually meet the consumers that enjoy the final products of their work. This may well change as production networks become more closely coordinated and operate with more intimate understanding of final markets.

The emerging economic systems could create a work environment that is more rewarding in a variety of ways. They can also lead to problems. Ironically many of the advantages and liabilities emerge from the same factors. Flexible production systems often require skills that are quite general; the employee is expected to learn the specifics of a new task quickly. This provides employees with greater freedom, but it can also weaken their bargaining power and make employment more tenuous. This, in turn, can lead to an increase in use of part-time and temporary employees, and can tempt employers to achieve flexibility through "disposable" workers. Technology may also be used to create an enormous gap between well paid, creative professionals and employees given narrowly defined tasks who are monitored electronically.

While many new jobs do not expose workers to the risks of traditional industrial accidents, stress can be greatly increased in a poorly designed office environment. Many of the most dangerous, least skilled, and most poorly paid jobs in the economy are unlikely to be affected by new technology or structural change. Farm laborers, food preparers, hospital orderlies, and other occupations seem likely to remain those of poorly paid minorities.

The following three chapters address these issues with the following plan:

- *Chapter 10* builds on the analysis of changing business structures to explore changing networks of people at work. It begins by showing how occupations of each type enter the production recipes of different businesses. Changing patterns of jobs created by each business sector are explained by examining changes in final demand, trade, production recipes, and labor productivity. The chapter also examines changing patterns of occupations, finding that these changes depend primarily on changes in staffing *within* each business type.
- *Chapter 11* shows how changes in the supply of labor and changes in demand implicit in the new economic structure combine to change the quality of jobs. The chapter explores the changing demand for skills, forces affecting the distribution of wages and compensation, employee and employer demands for flexibility, job safety, and factors affecting aspects of job satisfaction not easily measured in quantitative terms. In particular, the discussion examines the rapid changes occurring in the rules governing connections between skills and wages. Inequality in education may well become the most significant source of wage inequality.
- *Chapter 12* provides a different perspective on these issues by taking a more detailed look at changes in the way different production networks create jobs. Some of the structural changes *within* business types that remained a mystery in chapter 10 can only be explained by looking at factors affecting work in places like hospitals, farms, and grocery stores.

Chapter 10

How America Uses People at Work

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Chapter 10

How America Uses People at Work

LABOR IN THE PRODUCTION RECIPE

The jobs created by the American economy in the 1980s often bear little resemblance to the jobs of the early 1970s. Employment in manufacturing continues to fall while jobs in transactional enterprises have increased rapidly. If current trends continue, each sector will contribute roughly 16 percent of U.S. jobs in the early 1990s. Of all jobs added between 1980 and 1986, 85 percent were classified as "managerial, professional, technical, sales, or administrative support." These categories were responsible for less than half of all jobs in 1972.

Building on the analysis of structural change in production undertaken in chapter 5, this chapter explores the forces responsible for some of these changes. The discussion attempts to explain recent trends, and provides the basis for examining choices about how skills can be combined to produce amenities in the future. The analysis begins by describing how labor enters the production recipes; it next closes the circle introduced in figure 1-2 of chapter 1 by explicitly calculating the mix of skills required to achieve each amenity. The chapter then describes recent trends in U.S. jobs—both by business and occupation categories. Lastly, the analytical tools introduced at the beginning of the chapter are used to explain how the direct and indirect effects of changes in domestic demand, trade, productivity, and shifting production recipes are responsible for different patterns of employment.

While there are some exceptions, productivity, domestic demand, trade, and production recipes have all led to declining employment in manufacturing and increasing employment in transactional firms. In most cases, however, shifts in household and government consumption (final demand) and changes in production recipes (intermediate demand) seem to have had a larger impact on employment than changes in productivity. New patterns of trade and new patterns of domestic consumption have played approximately equal roles.

It appears, however, that changes in hiring *within* business sectors like farming, banking, or textile manufacturing have had a much greater effect on the shifting mix of skills in the American economy than changes in the net jobs created by each business. It is difficult to use available statistics to explore the change in occupations within business types. For this, it is necessary to appeal to the more qualitative analysis of chapter 12.

Accounting by categories of jobs and job types avoids many of the empirical difficulties encountered in chapter 5, which traced changes in "constant dollar" value-added contributed by different business categories. This occurs for several reasons:

- Jobs provide a more reliable measure of change—unlike prices, the basic unit does not change over time.
- Using job types avoids the problem of defining a "manufacturing" or "service" enterprise. Job classifications provide a way of seeing whether a manufacturing firm is also engaged in activities not usually classified as "manufacturing."
- Measuring job changes provides a way to trace the results of research and development through complex networks. It would seem. for example, that the Recreation and Leisure network does comparatively little research. In fact, one dollar spent on Recreation and Leisure generates as much work for scientists and engineers as the average dollar spent in the economy as a whole.

Introducing People Into the Production Recipe

The tables in chapter 4 traced the interconnections that exist in the U.S. economy, by showing how U.S. businesses combine products purchased from other businesses (intermediate inputs) with their own "value-added" to produce output. Chapters 5 and

6 discussed changes in the share of GNP (the sum of all value-added) made by the various sectors, how businesses are organized to generate this value, and how patterns in which businesses purchase products and services from each other have changed. The challenge of the present discussion is to describe changes *within* the value-added portion of the production recipe.

Value-added consists of three components:

1. property-type income (the returns paid to investors and any income of self-employed persons)—approximately one-third of all value-added;
2. indirect business taxes (a category that includes most taxes other than corporate income taxes), which account for around 8 percent of value-added; and
3. compensation paid to employees with different skills which represents the bulk, 59 percent, of value-added.[1]

The first two categories have relatively straightforward interpretations and are discussed in greater detail in chapter 11. Since compensation paid to employees for their associated skills is such a large part of the value-added portion of the production recipe and represents the contribution of labor to the economy, it is the object of interest for this chapter.

Trends in the share of value-added paid to employee compensation in several specific businesses categories are shown in table 10-1. The gradual convergence in patterns of sector organization described in Part II can also be seen in this table. In general, the percent of value-added paid to employees increased for sectors with comparatively low ratios in 1956 (farming; mining; finance, insurance, and real estate; health services; legal services; and auto repair). Many of these sectors approached the 0.7 ratio that has been typical of manufacturing.

Technology and market structures have had uneven effects on compensation. The compensation to value-added ratio increased in areas like legal and health services, where capital invested per worker has grown (statistics on capital investment are provided later in this chapter—see table 10-9). The ratio fell in some heavily capitalized businesses, such as telephone and public utilities (electric, gas, and sanitary services). Very little of the value-added in heavily capitalized real estate businesses is paid as compensation.

A Taxonomy for Skills

Lacking any good alternative, the skills people contribute to production can be measured using occupation categories. As has been the case in so many parts of this analysis, the selection of occupation categories is no easy task. Critical changes can be missed if the wrong units are selected to measure change. While the U.S. Bureau of Labor Statistics takes great pains to maintain a consistent set of occupation descriptions, and to update them when necessary, enormous ambiguities remain—some of the greatest of which are found in precisely the occupations where the fastest growth is occurring. A work force moving rapidly to new jobs built around advanced information equipment or networks of semiautonomous work teams does not fall into convenient categories.

Two sets of occupation categories are used in the discussion:

- The 16 occupations summarized in box 10-A were selected because they expose areas where the most rapid occupation changes are occurring.
- Use of the 11 summary categories, shown in table 10-2, were made necessary by a major change in the occupation classification system in 1980 that makes more detailed comparisons between the 1970s and 1980s impossible.[2]

A table providing more detail on both systems appears in the Appendix.

Skills in the Production Recipe

Using pay as a proxy for the contribution made by each occupation, table 10-2 describes how skills enter production recipes, showing how much and what kind of employment is needed to produce a unit of output. Table 10-2 is identical to table 4-2 of chapter 4, except that table 10-2 provides more

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[1] Percentage breakdown of value-added is based on the "1977 Input-Output Tables," *Survey of Current Business*, vol. 64, No. 5, May 1984.

[2] See John Tschetter, "Producer Services Industries: Why Are They Growing So Rapidly?" *Monthly Labor Review*, vol. 110, No. 12, December 1987, pp. 31-41.

Table 10-1.—Compensation as a Percent of Value-Added by Selected Businesses

	1956	1966	1976	1986
All private industries	52.8%	52.7%	54.4%	54.3%
Natural Resources				
Agriculture, forestry, and fishery services	15.8	18.5	18.9	21.3
Mining	34.4	35.2	31.8	32.2
Electric, gas, and sanitary services	34.3	30.1	29.8	28.2
Construction	70.0	70.4	67.1	67.3
Manufacturing	68.0	66.5	70.0	70.0
Fabricated metal products	80.0	76.8	74.7	74.9
Food and kindred products	58.7	56.0	58.8	60.3
Apparel and other textile products	86.6	84.2	85.1	82.2
Machinery, except electrical[a]	72.8	71.1	73.6	80.3
Instruments and related products	76.9	69.9	76.1	74.0
Motor vehicles and equipment	56.4	49.3	67.5	78.0
Chemicals and allied products	53.4	53.8	55.1	62.8
Transportation and Trade				
Transportation	65.3	63.8	67.4	63.9
Wholesale trade	53.6	54.4	54.5	56.7
Retail trade	56.3	58.7	59.8	59.0
Transactional Activities				
Telephone and telegraph	52.5	43.3	47.1	41.5
FIRE[b]	18.7	19.2	23.1	26.6
Business services	60.8	67.0	63.6	62.1
Legal services	22.5	22.6	40.8	53.9
Personal Services				
Hotels and other lodging places	57.6	57.8	58.6	65.3
Automobile repair and services	39.7	39.7	38.6	43.3
Amusement and recreation services	47.4	51.8	60.4	63.2
Social Services				
Health services	41.5	49.0	71.7	76.6
Educational services	84.8	93.7	93.4	93.6
Social services and membership organizations	98.8	98.4	98.5	97.7

[a] Includes production of computers.

[b] Finance, insurance, and real estate includes U.S. Department of Commerce imputations for owner-occupied housing.

NOTE: Only a sample is shown for some categories.

SOURCE: Based on U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, Tables 6.1 and 6.4.

detail on the value-added portion of the production recipes while table 4-2 provided more detail on intermediate inputs. Both show that value-added in manufacturing is a comparatively small fraction of the total value of manufacturing output, since manufacturing businesses are more highly linked to other parts of the economy by intermediate inputs. But table 10-2 reveals that certain occupations, like executives and managers or administrative support workers, are endemic to all sectors; others, such as machine operators or professional specialties, are relatively concentrated in one or two sectors. The table also shows the relative importance of skill in the production recipes of the sectors. For example, per unit of output, the Social Services sector uses a greater amount of inputs from the administrative support occupation than High Wage Manufacturing uses from all of the blue-collar occupations (precision production, craft, & repair; machine operators, assemblers, & installers; and transportation & material moving).

The direct contribution employment and its associated skills makes to a sector's production recipe depends on the interaction of two factors: the staffing pattern of the sector, and the compensation paid for a particular skill or occupation.

The factors connecting skills and wages are obviously complex. The summary data in table 10-3 show the difficulty of using occupations as a proxy for skills. Wages, for example, do not necessarily correlate to experience or levels of education. A variety of factors, such as skillful union bargaining, discrimination on the basis of race, age, and sex, and measurable forces of supply and demand, interact to establish wages. Wages in the service industries, for

Box 10-A.—Selecting Occupations

1. *Managers and Management Support* include executives, administrators, and support occupations like accountants and tax examiners.
2. *Technical Professionals* include engineers; natural, computer, and mathematical scientists; and architects and surveyors.
3. *Education and Health Professionals* include teachers, librarians, counselors, physicians, registered nurses, therapists, and other medical professionals.
4. *Other Professionals and Related Support* include social scientists, social workers, ministers, lawyers, judges, writers, artists, soothsayers, entertainers, and athletes.
5. *Technicians, and Related Support* include drafters, computer programmers, licensed practical nurses, surgical technicians, air traffic controllers, paralegals, and other technicians working in health, engineering, and the sciences.
6. *Sales Workers* include cashiers, insurance agents, reai estate agents, travel agents, and a variety of other marketing and sales occupations.
7. *Other Customer Contact* workers include occupations directly involved with customers but not involved in sales. These include receptionists, insurance adjusters, and hotel desk clerks.
8. *Information Distribution* occupations include telephone operators, mail carriers, duplicating machine operators, meter readers, stock clerks, dispatchers, and other people responsible for keeping records, scheduling, dispatching, and distribution.
9. *Data Entry, Manipulation, and Processing* workers include computer operators, bookkeepers, secretaries, file clerks, tellers, and other office occupations.
10. *Food and Beverage Preparers* include most workers in restaurants and other commercial and institutional food service firms (e.g., bartenders, cooks, waiters, and waitresses).
11. *Other Service Workers* include, firemen, police. guards, child care workers, nursing aids, flight attendants, barbers, janitorial servicces, and private household workers.
12. *Precision Production, Craft, and Repair* occupations include the most highly skilled of the "blue collar" workers and their supervisors. The category includes machinists, tool and dye makers, the construction trades, mine workers, mechanics, and repair workers.
13. *Machine Operators, Assemblers, and Inspectors* involve more routine blue-collar work: machine set-up and operation, machine tending, and a variety of hand-work occupations such as hand sewers and welders.
14. *Transportation and Material Moving* workers include aircraft pilots, drivers of trucks, buses, and other equipment, and operators of forklifts and other industrial vehicles.
15. *Handlers, Equipment Cleaners, Helpers, and Laborers* are the lowest paid blue-collar workers. The jobs include refuse collectors, hand backers, and vehicle washers.
16. *Farming, Forestry, and Fishery* occupations include farm managers and supervisors as well as farm workers.

SOURCE: Based on classifications provided by the U.S. Department of Labor, Bureau of Labor Statistics.

example, have grown faster than measured productivity. This is presumably because employees in service enterprises gained some share of the productivity increases generated elsewhere in the economy.[3] Chapter 11 discusses a number of reasons for believing that the connections between occupations and wages shown in table 10-3 will change during the next decades.

Table 10-4 avoids some of the problems inherent in accounting by wages, showing only the jobs required in each sector of the U.S. economy and each sector's occupational staffing pattern. The table, of course, suffers from a limitation of its own—it cannot show how much each occupation contributes to the value-added in each industry. But it does show the mix of skills employed by each sector and how members of certain occupations are distributed across the sectors of the economy.

Tables 10-2 and 10-4 provide two perspectives on the way people enter production recipes that are use-

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[3] This effect, sometimes known as the "Baumol disease," is described in W.J. Baumol, "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis," *American Economic Review*, June 1967, pp. 415-426.

Table 10-2.—A Production Recipe Including Labor

	Natural Resources	Construction	Manufacturing			Transportation & Trade	Transactional Activities	Personal Services	Social Services
			Low	Medium	High				
Total Intermediate Inputs	53.3%	56.8%	63.5%	63.7%	70.4%	39.2%	27.2%	41.0%	21.7%
Value-Added	46.7	43.2	36.5	36.3	29.6	60.8	72.8	59.0	78.3
Property-Type Income	31.4	7.1	10.6	10.9	8.3	13.6	40.9	21.8	5.0
Indirect Business Taxes	3.5	1.1	1.1	1.7	2.2	9.6	9.9	3.5	0.2
Compensation	11.8	35.0	24.9	23.7	19.0	37.6	22.0	33.7	73.0
Executive, Administrative, & Managerial	1.3	6.4	2.1	3.0	2.4	6.1	5.7	5.1	8.9
Professional Specialty	1.0	0.6	0.4	2.1	2.0	1.0	2.7	2.7	30.4
Technical & Related Support	0.3	0.3	0.2	0.8	0.6	0.3	0.9	0.3	3.8
Sales	0.1	0.4	0.5	0.9	0.4	11.0	1.4	2.2	0.4
Administrative Support (including clerical)	1.2	2.2	1.9	2.7	1.7	5.1	7.6	2.8	12.5
Service Occupations	0.1	0.2	0.2	0.3	0.2	5.3	1.5	12.6	10.0
Precision Production, Craft, and Repair	2.8	18.0	5.3	4.9	5.2	3.6	1.5	4.0	3.8
Machine Operators, Assemblers, and Inspectors	0.3	0.6	11.2	6.7	4.8	0.4	0.2	1.5	0.6
Transportation and Material Moving	0.9	2.4	0.7	1.1	0.8	3.6	0.2	1.0	1.6
Handlers, Equipment Cleaners, Helpers, and Laborers	0.5	3.8	2.0	1.2	1.0	1.2	0.3	0.7	0.8
Farming, Forestry, and Fishing	3.1	0.0	0.3	0.0	0.0	0.0	0.1	0.8	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

How To Read This Table: $100 in output from Natural Resource Businesses combined $53.30 of materials purchased from other businesses with $46.70 of value-added in Natural Resource businesses. The value-added paid included the following: $31.40 was in the form of returns to capital, $1.30 was paid as compensation to executives, administrators, and managers, $1.00 was for compensation to professionals (mostly scientists and engineers), and $1.20 was paid to clerks and other administrative support personnel.

NOTE: See appendix for a key to the occupations classification scheme. Numbers may not add due to rounding.

SOURCES: 1977 Input/Output Table, *Survey of Current Business*, May 1984, used for decomposition of value-added; 1980 Input/Output Tables, Bureau of Economic Analysis, unpublished; 1984 Occupation by Industry Employment Matrix, Bureau of Labor Statistics, unpublished; Table 5, "Median Weekly Earnings for Wage and Salary Workers in 1984," Bureau of Labor Statistics, adjusted to include compensation; U.S. Department of Labor, "Total Employment By Occupation, 1984," adjusted to account for self-employed workers, unpublished.

Table 10-3.—Characteristics of the Occupations, 1984

Occupation[a]	Median earnings[b] ($ weekly)	Percent female	Percent black[c]	Education[d]		Age		Unemployment rate
				Percent high school	Percent college	Percent 16-24	Percent 25-54	
Executive, Administrative, and Managerial	$483	33.6%	6.1%	49.6%	45.0%	7.5%	79.6%	2.7%
Professional Specialty	455	48.5	6.7	24.1	74.5	8.0	81.8	2.5
Technicians & Related Support	379	48.1	20.5	67.9	28.6	23.1	70.1	2.9
Sales	319	47.9	12.4	65.4	21.0	24.8	64.1	5.4
Administrative Support (including clerical)	275	79.9	11.6	82.0	11.0	21.3	68.1	5.1
Private Household Services	134	96.2	29.6	42.3	1.6	30.9	51.0	6.9
Protective and Other Services	232	58.2	23.7	63.2	5.7	31.4	58.3	9.2
Precision Production, Craft, and Repair	384	8.5	7.9	70.9	5.4	16.0	73.2	7.5
Machine Operators, Assemblers, and Inspectors	277	41.1	13.9	61.0	2.8	18.6	70.1	10.7
Transportation and Material Moving	344	8.3	15.1	63.4	3.1	15.8	72.7	9.2
Handlers, Equipment Cleaners, Helpers, and Laborers	251	16.6	22.7	60.1	2.6	43.3	49.9	15.1
Farming, Forestry, and Fishing	203	15.6	8.0	52.2	7.9	24.2	61.8	8.5
Average	326	43.7	10.1	60.0	22.1	19.7	69.5	6.6

[a] See appendix for a key to the occupations classifications scheme. Service occupations are here broken out into "private household" and "protective and other."
[b] Median earnings data in current dollars, calculated for "wage and salary workers who usually work full-time."
[c] Race data compiled from *Employment and Earnings*, annual review issue. Data are for 1985.
[d] Educational attainment data collected from annual survey (not annual averages).

SOURCE: Office of Technology Assessment, 1988, based on unpublished data provided by the U.S. Department of Labor, Bureau of Labor Statistics.

ful for understanding recent patterns of change. For example:

- Although High Wage Manufacturing only spends about 4 cents per dollar of output on inputs from the Transactional Activities sector (see table 4-2 of ch. 4), it spends nearly twice that amount (7.1 cents) on labor inputs that would be considered transactional: managers, professional specialists, technicians, sales workers, and administrative support workers.
- About one-quarter of all jobs in Social Services (dominated by teaching and health activities) are held by individuals requiring professional training, making this by far the most highly educated sector.
- Over three-quarters of the managers and management support jobs are in the service sectors.
- About one out of eight jobs fall into the data entry, manipulation, and processing occupations —more than double the number employed as food and beverage preparers. The data entry occupation represents nearly one-third of all jobs in the Transactional Activities sector.
- More people work in Transportation & Trade than in all of manufacturing and Construction combined.

The remaining element connecting jobs and skills to structural changes in the economy is the unseen, indirect requirement for different types of labor generated through firms' purchases of inputs needed for their production recipes. Using methods described in chapter 4 (and data in tables 10-2 and 10-4), table 10-5 traces the links connecting the natural resources & construction, manufacturing, and service sectors in 1984.[4] The impact of sectoral linkage on the work force is similar to that found for value-added (table 4-4 of chapter 4) and trade (table 7-10 of chapter 7). Demand for manufacturing and natural resource & construction products tends to generate a significant portion of jobs outside these sectors, while the service sector tends to be relatively insular.

Fully 14 percent of all service sector jobs result indirectly from demand for the natural resource and manufacturing products; manufacturing alone was

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[4] The table shows only domestic jobs, since imports have been removed using methods described in ch. 7.

Table 10-4.—Employment by Occupation and Industry, 1984

	Natural Resources	Construction	Low Wage Manuf.	Med. Wage Manuf.	High Wage Manuf.	Transportation and Trade	Transactional Activities	Personal Services	Social Services	Total	Millions of Jobs
Percent of all jobs in each occupation, by sector:											
Managers and Management Support	2.2%	5.9%	2.3%	8.1%	5.0%	26.9%	22.3%	4.7%	22.6%	100.0%	11.3
Technical Professionals	6.3	2.4	1.6	21.0	18.3	5.8	23.5	0.3	20.9	100.0	2.1
Education and Health Professionals	0.3	0.0	0.0	0.1	0.0	1.7	1.0	1.4	95.4	100.0	7.1
Other Professionals	1.5	0.3	0.6	6.3	2.1	8.1	21.0	5.9	54.2	100.0	3.6
Technicians	2.6	1.4	1.0	11.3	7.0	6.2	18.2	1.4	50.9	100.0	3.2
Sales Workers	0.4	0.6	0.9	3.9	1.3	79.0	8.9	3.3	1.8	100.0	11.2
Other Customer Contact	1.8	0.2	0.4	1.0	0.4	15.2	40.3	11.6	29.2	100.0	1.3
Information Distribution	1.8	0.7	3.4	9.0	5.1	35.8	15.3	1.5	27.3	100.0	3.8
Data-entry, Manipulation, and Processing	2.1	2.5	1.9	6.8	3.2	18.2	31.4	2.0	31.9	100.0	13.6
Food and Beverage Preparers	0.1	0.0	0.0	0.1	0.0	72.2	0.7	9.1	17.9	100.0	6.6
Other Service Workers	0.5	0.4	0.7	1.7	1.2	7.0	14.2	22.9	51.5	100.0	9.9
Precision Production, Craft, and Repair	5.7	19.2	7.1	15.3	12.5	18.1	6.7	4.3	11.2	100.0	12.5
Machine Operators, Assemblers, and Inspectors	1.2	1.2	27.0	37.7	21.0	4.1	1.8	2.9	3.1	100.0	8.2
Transportation and Material Moving	5.3	7.3	2.8	9.4	5.2	51.2	2.3	3.1	13.4	100.0	4.7
Handlers, Equipment Cleaners, and Helpers	4.4	16.7	10.9	15.0	9.8	24.2	5.5	3.2	10.2	100.0	4.2
Farming, Forestry, and Fishing	70.9	0.3	4.2	1.0	0.4	0.6	4.5	9.7	8.4	100.0	3.6
Total (percent)	4.5	4.5	4.5	9.3	5.7	26.3	12.8	5.6	26.8	100.0	106.8
Percent of all jobs in each sector, by occupation:											
Managers and Management Support	5.2%	13.8%	5.6%	9.2%	9.2%	10.8%	18.4%	8.8%	8.9%	10.6	
Technical Professionals	2.8	1.1	0.7	4.5	6.4	0.4	3.6	0.1	1.6	2.0	
Education and Health Professionals	0.5	0.0	0.0	0.0	0.0	0.4	0.5	1.7	23.8	6.7	
Other Professionals	1.1	0.2	0.4	2.3	1.2	1.0	5.4	3.5	6.7	3.3	
Technicians	1.8	0.9	0.7	3.6	3.7	0.7	4.2	0.7	5.7	3.0	
Sales Workers	0.8	1.4	2.2	4.4	2.4	31.4	7.2	6.1	0.7	10.5	
Other Customer Contact	0.5	0.1	0.1	0.1	0.1	0.7	3.7	2.4	1.3	1.2	
Information Distribution	1.5	0.5	2.8	3.5	3.2	4.9	4.3	0.9	3.7	3.6	
Data-entry, Manipulation, and Processing	6.0	7.1	5.5	9.3	7.1	8.8	31.2	4.5	15.2	12.7	
Food and Beverage Preparers	0.1	0.0	0.0	0.1	0.0	17.0	0.3	10.0	4.1	6.2	
Other Service Workers	0.9	0.8	1.5	1.7	2.0	2.5	10.3	37.8	17.9	9.3	
Precision Production, Craft, and Repair	15.0	50.2	18.6	19.2	25.6	8.0	6.1	9.0	4.9	11.7	
Machine Operators, Assemblers, and Inspectors	2.1	2.1	46.5	31.0	28.1	1.2	1.0	3.9	0.9	7.6	
Transportation and Material Moving	5.2	7.2	2.7	4.4	4.0	8.5	0.8	2.4	2.2	4.4	
Handlers, Equipment Cleaners, Helpers	3.9	14.5	9.5	6.3	6.7	3.6	1.7	2.2	1.5	3.9	
Farming, Forestry, and Fishing	52.7	0.2	3.2	0.4	0.2	0.1	1.2	5.7	1.0	3.3	
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Millions of jobs	4.8	4.8	4.8	9.9	6.1	28.1	13.7	6.0	28.6	106.8	

How To Read This Table: 2.2% of all managers and management support jobs are provided by natural resource businesses (top table). 5.2% of all jobs in Natural Resource businesses go to managers and management support (bottom table).

NOTE: Employment displayed is for wage and salary jobs adjusted for the self-employed. The 16 occupation categories listed here accord with the 11 listed in table 10-2, except that certain occupations are subdivided for a more complete listing of occupation categories (e.g., "professional specialty" is subdivided into "technical professionals," "education & health professionals," and "other" (mostly law and science). Self-employed persons are accounted for through data provided by the Bureau of Labor Statistics. See the appendix for a key to the occupations classification scheme. Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, from 1984 Industry by Occupation Employment Matrix, developed by the U.S. Department of Labor, Bureau of Labor Statistics, Office of Economic Growth and Employment Projections.

Table 10-5.—1984 Wage and Salary Employment Generated From 1984 Demand for Natural Resources, Construction, Manufactured Products, and Services

Sector	1984 jobs (percent)	Percent of 1984 jobs resulting from 1984 demand for: Natural resources and construction	Manufacturing	Services
Natural Resources and Construction:				
Natural Resources	3.5%	12.8%	6.6%	1.2%
Construction	4.5	28.6	2.7	1.7
Subtotal	7.9	41.4	9.4	2.9
Manufacturing:				
Low Wage Manufacturing	4.6	4.5	15.8	1.0
Medium Wage Manufacturing	9.6	13.1	26.1	3.8
High Wage Manufacturing	5.9	6.1	18.9	1.7
Subtotal	20.0	23.7	60.8	6.5
Services:				
Transportation & Trade	26.3	19.8	18.0	29.9
Transactional Activities	13.0	12.2	9.2	14.3
Personal Services	5.5	1.4	1.6	7.4
Social Services	27.2	0.5	1.1	39.0
Subtotal	72.1	34.9	29.8	90.6
Total (percent)	100.0	100.0	100.0	100.0
Total (millions of jobs)	96.9	9.2	21.2	66.6

How To Read This Table: In 1984, demand for natural resource and construction products, indirectly and directly, generated 9.2 million jobs, 41.4 percent of which were in the Natural Resource sector, 23.7 percent were manufacturing jobs, and 34.9 percent were service sector jobs.

SOURCES: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, various tables; and "1980 Input/Output Tables, unpublished; U.S. Department of Labor, Bureau of Labor Statistics, "1984 Occupation by Industry Matrix," unpublished; and 1984 trade estimates, rebased from $1977 to $1980, unpublished.

responsible for 1 out of 11 service jobs. Of the service jobs created indirectly, 72 percent appeared in three industries: wholesale & retail trade, business services, and transportation & warehousing.[5] Purchases of manufactured goods were responsible for nearly one-quarter of all transportation and warehousing workers, 23 percent of all business service jobs, and 16 percent of all wholesale and retail employees in 1984. Although a strong link exits between the demand for manufacturing goods and service sector jobs, the natural resources & construction sector contributes proportionately more to service sector employment than does manufacturing.

Of the 86 percent of service jobs created directly through demand for service products, nearly 90 percent appear in six industries: wholesale & retail trade (28 percent), government (25 percent), health, education, & social services (17 percent), business services (9 percent), and eating & drinking places (9 percent). Demand for service products indirectly created about the same number of jobs in the manufacturing sector as the number of service sector jobs created by demand for manufactured goods, albeit at a proportionately much lower rate.

Some manufacturers depend heavily on demand from service industries. Aircraft manufacturers, for example, sell primarily to airlines. Over half of all the jobs in the furniture & fixtures (non-household) industry were generated through demand for service products, presumably an indirect result of furnishing service industry office buildings. A similar situation held for 46 percent of printing & publishing jobs, 39 percent of the service industry machine employees, and 34 percent of the scientific and controlling instruments workers.

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[5] This analysis does not attempt to factor in the indirect effect of manufacturing workers spending their wages on service products like travel, and on the service jobs that might be produced in the process. Rather, this analysis merely looks at the indirect effect caused by manufacturing businesses purchasing service inputs for their production recipes. For further analysis on the connections between manufacturing and business services see Bobbie H. McCrackin, "Why Are Business and Professional Services Growing So Rapidly?" *Economic Review*, Federal Reserve Bank of Atlanta, August 1985; and John Tschetter, op. cit., footnote 2.

Closing the Circle: Converting Skills to Amenity

Using methods similar to those employed in chapter 4 to convert value-added by production sectors into categories of amenity, the jobs and occupations needed to provide the amenities can also be calculated. These estimates, shown in table 10-6, complete the circuit outlined in chapter 1. They trace value from the labor offered by households to the amenities received for their skills.

The table is an interesting measure of the distance the economy has moved from subsistence. A table computed for a developing economy (or indeed the American economy of 1874) would show most jobs involving farming or manual labor used to provide basic food and housing. In 1984, however, less than one-third of all American workers were directly or indirectly involved in the provision of the Food and Housing amenities. Only about 11 percent of these workers were farmers or other laborers. Most were managers, professionals, technicians, service workers, or sales workers.

Health, Education, and the Government employ disproportionately large numbers of professionals. The U.S. Department of Defense is responsible for about 7.2 percent of all jobs in the economy, but one-third of these jobs are categorized as managers and professionals.

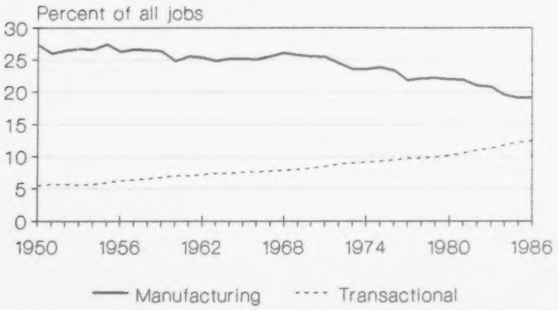
Managers and administrators account for about 10 percent of all jobs in most amenity categories, and administrative support occupations (such as clerks and secretaries) provide about one-sixth of the jobs needed. Not surprisingly, most sales employees work to provide Food (restaurant and grocery sales), Housing (real estate), Transportation (travel), and Clothing and Personal Care (clothing sales). Over one-third of all manual jobs, including precision craft jobs, are involved in the production of Food and Housing.

TRENDS IN NET JOB GENERATION AND LOSS

The data just introduced will be used to explore the forces driving changes in U.S. job creation during the last decade. Before proceeding, it is worth reviewing the nature of these changes in greater detail:

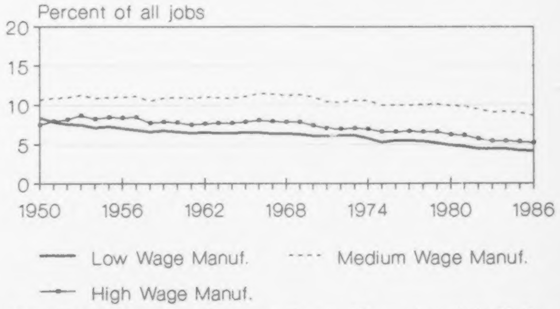
- A steady 30-year decline in the manufacturing sectors' share of employment has been almost exactly offset by increases in Transactional Activities (see figure 10-1a). Taken together, Low and High Wage Manufacturing lost more than one million full-time jobs between 1978 and 1986 (see figure 10-1b). Manufacturing was the only sector to lose jobs over this time period.
- Between 1950 and 1975, the share of employment lost by Natural Resource businesses (primarily farming) was almost exactly off-set by the increased share of Social Services (dominated by education, medicine, and government). Both

Figure 10-1a.-Manufacturing and Transactional Activities Jobs as a Percent of All Jobs



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.10.

Figure 10-1b.-Low Wage, Medium Wage, and High Wage Manufacturing Job as a Percent of All Jobs



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.10.

Table 10-6.—Jobs Required To Supply Different Kinds of Amenity in 1984

	Food	Housing	Transportation	Health	Clothing and Personal Care	Education	Personal Business and Communication	Recreation and Leisure	Government n.e.c.	Federal Defense	Exports	Total	Millions of jobs
Percent of jobs in each occupation category, by amenity network:													
Managers and Management Support	14.5%	15.1%	8.3%	12.1%	6.6%	7.9%	8.8%	7.8%	5.0%	7.1%	6.8%	100.0%	11.3
Technical Professionals	9.6	13.9	8.0	9.1	4.5	9.5	6.2	6.9	5.7	14.1	12.5	100.0	2.1
Education and Health Professionals	1.5	1.1	1.1	30.9	0.7	27.0	1.2	7.3	12.6	16.1	0.4	100.0	7.1
Other Professionals	7.1	7.3	4.0	23.9	3.5	15.0	5.9	11.9	7.4	9.9	4.1	100.0	3.6
Technicians	6.8	9.4	4.9	26.0	3.4	12.3	5.2	9.2	6.2	9.5	6.9	100.0	3.2
Sales Workers	23.8	17.0	12.7	6.3	13.0	2.0	4.7	8.8	1.9	2.6	7.2	100.0	11.2
Other Customer Contact	7.7	10.2	6.7	18.3	6.4	7.5	19.4	9.5	4.7	5.0	4.6	100.0	1.3
Information Distribution	16.1	17.4	9.5	9.3	8.9	5.4	7.7	7.8	3.7	5.9	8.3	100.0	3.8
Data-Entry, Manipulation, and Processing	10.3	12.3	7.0	15.2	5.3	10.5	12.5	7.2	6.0	7.9	5.7	100.0	13.6
Food and Beverage Preparers	56.2	4.8	2.7	10.2	4.3	3.0	2.2	7.6	2.8	3.7	2.5	100.0	6.6
Other Service Workers	6.1	18.8	3.0	22.2	4.8	13.4	3.5	10.5	6.6	8.4	2.8	100.0	9.9
Precision, Production, Craft, and Repair	13.4	22.9	11.1	7.3	7.2	6.2	3.9	6.8	4.8	6.9	9.4	100.0	12.5
Machine Operators, Assemblers, and Inspectors	13.4	17.1	10.0	6.2	16.7	3.1	2.8	7.6	2.7	6.8	13.6	100.0	8.2
Transportation and Material Moving	18.6	17.8	13.4	7.3	6.7	6.8	2.3	7.1	4.8	6.1	9.2	100.0	4.7
Handlers, Equipment Cleaners, and Helpers	17.4	22.2	10.4	7.1	8.3	6.0	2.8	6.6	4.7	5.7	8.8	100.0	4.2
Farming, Forestry, and Fishing	43.7	15.6	1.7	4.7	1.9	4.3	0.9	7.2	2.3	2.5	15.4	100.0	3.6
Total (percent)	16.3	14.8	7.6	13.0	7.0	8.6	5.5	8.0	5.1	7.2	7.0	100.0	106.8
Percent of jobs in each amenity category, by occupation:													
Managers and Management Support	9.4%	10.8%	11.5%	9.8%	9.9%	9.7%	17.1%	10.3%	10.3%	10.4%	10.3%	10.6	
Technical Professionals	1.2	1.9	2.1	1.4	1.3	2.2	2.3	1.7	2.2	3.9	3.6	2.0	
Education and Health Professionals	0.6	0.5	1.0	15.8	0.6	21.0	1.4	6.1	16.5	15.0	0.4	6.7	
Other Professionals	1.4	1.7	1.8	6.1	1.7	5.8	3.6	5.0	4.8	4.6	2.0	3.3	
Technicians	1.3	1.9	1.9	6.0	1.5	4.3	2.9	3.4	3.6	4.0	3.0	3.0	
Sales Workers	5.2	12.0	17.6	5.1	19.4	2.4	9.0	11.6	3.9	3.8	10.8	10.5	
Other Customer Contact	0.6	0.8	1.0	1.7	1.1	1.0	4.2	1.4	1.1	0.8	0.8	1.2	
Information Distribution	3.5	4.3	4.5	2.6	4.6	2.2	5.1	3.5	2.6	2.9	4.3	3.6	
Data-Entry, Manipulation, and Processing	8.0	10.6	11.8	14.8	9.6	15.6	29.3	11.4	15.1	14.0	10.4	12.7	
Food and Beverage Preparers	21.4	2.0	2.2	4.9	3.9	2.2	2.5	5.9	3.4	3.2	2.3	6.2	
Other Service Workers	3.5	11.8	3.6	15.9	6.4	14.5	6.0	12.3	12.0	10.9	3.7	9.3	
Precision, Production, Craft, and Repair	9.6	18.1	17.1	6.6	12.1	8.5	8.4	10.0	11.0	11.3	15.7	11.7	
Machine Operators, Assemblers, and Inspectors	6.3	8.9	10.1	3.6	18.2	2.8	4.0	7.2	4.1	7.3	14.9	7.6	
Transportation and Material Moving	5.0	5.3	7.7	2.5	4.2	3.5	1.8	3.9	4.1	3.7	5.8	4.4	
Handlers, Equipment Cleaners, and Helpers	4.1	5.9	5.3	2.1	4.7	2.7	2.0	3.2	3.6	3.1	4.9	3.9	
Farming, Forestry, and Fishing	8.9	3.5	0.7	1.2	0.9	1.6	0.5	3.0	1.5	1.1	7.3	3.3	
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Millions of jobs	17.5	15.8	8.1	13.9	7.5	9.2	5.8	8.5	5.4	7.7	7.5	106.8	

NOTE: Employment displayed is for wage and salary jobs adjusted for the self-employed. The 16 occupation categories listed here accord with the 11 listed in table 10-2, except that certain occupations are subdivided for a more complete listing of occupation categories (e.g., "professional specialty" is subdivided into "technical professionals," "education & health professionals," and "other" (mostly law and science). Self-employed persons are accounted for through data provided by the Bureau of Labor Statistics. See the appendix for a key to the occupations classification scheme. Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, from 1984 Industry by Occupation Employment Matrix, developed by the U.S. Department of Labor, Bureau of Labor Statistics, Office of Economic Growth and Employment Projections and U.S. Department of Commerce, Bureau of Economic Analysis, "1980 Input-Output Tables," unpublished.

sectors have held a relatively constant share of all jobs since 1975 (see figure 10-1c).

- The share of employment held by Construction, Transportation & Trade, and Personal Services has not changed significantly since 1950 (see figure 10-1d). The steady share of jobs held by the Transportation & Trade sector resulted from gains in wholesale and retail trade, which were offset by losses in transportation. Construction employment is highly cyclical.
- Government employment (including defense) peaked in 1970. Federal civilian employment is now below the levels of 1950. State and local governments gained share through 1980.[6]

Accounting for Changes in Job Share

Changes in each business' share of U.S. employment are driven by the forces described in earlier chapters: domestic demand, production recipes, and trade patterns. The effect of these forces on the changing value-added contributions of each major business sector was traced in chapter 5. Clearly, any factor that changes the contribution a sector makes to the gross national product (GNP) affects the number of jobs contributed by that sector, depending on the productivity with which the sector uses labor. These effects are examined separately in table 10-7. Some highlights:

- Comparatively stable full-time-equivalent employment in Natural Resources during 1972-84 resulted from declining measured productivity (requiring more jobs for a given level of output), which offset the effects of declining domestic demand.
- Manufacturing's share of all employment fell sharply as a result of three effects: rising productivity, shrinking domestic markets for High Wage Manufacturing enterprises, and increasingly unfavorable terms of trade.
- Transportation and wholesale & retail employment grew both because of increased domestic and international demand and changes in production recipes.
- Explosive growth in transactional employment occurred because of comparatively slow productivity growth and rapid growth in demand for Transactional activities both as final and intermediate demand.

The major difference between table 10-7 and table 5-1 of chapter 5 is the addition of labor productivity. Labor productivity, or output per job in an industry, depends on the level of technology utilized, the quality of management, the capital invested per worker, and the skills, experience, and esprit of the staff. All of these factors are in flux.

Table 10-8 summarizes recent trends in productivity, as measured by output per hour worked. Output per hour in 1984 was comparatively high for Natural Resource and Medium and High Wage Manufacturing enterprises, and comparatively low for the poorly capitalized Personal and Social Services—this despite the fact that most workers in Social Services are relatively well educated.

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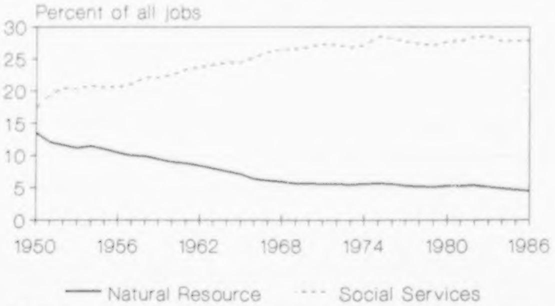
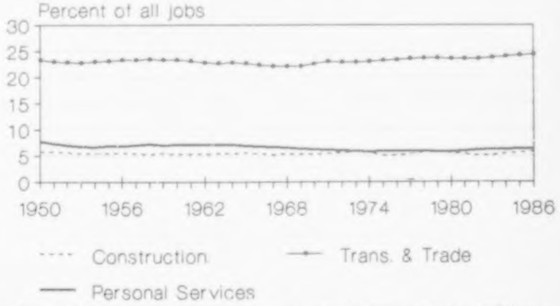
[6] U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.7b.

Figure 10-1c.-Natural Resource and Social Service Jobs as a Percent of All Jobs



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.10.

Figure 10-1d.-Construction, Personal Service, and Transportation & Trade Jobs as a Percent of All Jobs



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.10.

Table 10-7.—Changes in Industry Share of Full-Time Equivalent Employees (FTEs) from 1972 to 1984 for Various Factors

(in percent; numbers will not necessarily add due to rounding and interactive effects)

	Natural Resources	Construction	Low Wage Manufacturing	Medium Wage Manufacturing	High Wage Manufacturing	Transportation and Trade	Transactional Activities	Personal Services	Social Services[a]	Real Estate and Rental[b]
Job shift share	0.0	−0.5	−1.9	−1.3	−1.7	1.5	3.3	0.1	0.3	0.3
Productivity[c]	0.5	0.2	−0.8	−1.4	−0.5	−0.9	1.3	0.4	1.0	0.1
Production recipe and demand	−0.6	−0.8	−1.0	0.1	−1.1	2.3	2.0	−0.3	−0.8	0.1
Production recipe	−0.1	−0.0	−0.3	−0.2	−0.3	1.4	1.0	−0.2	−1.2	−0.1
Final demand	−0.5	−0.7	−0.6	0.2	−0.8	0.8	1.0	−0.1	0.5	0.1
Domestic demand	−0.5	−0.8	−0.0	0.4	−0.4	0.3	0.8	−0.1	0.2	0.1
Trade	−0.0	0.1	−0.6	−0.3	−0.3	0.5	0.2	0.0	0.4	0.0
Interactive	0.1	0.0	−0.1	0.0	−0.1	0.1	0.0	0.0	0.1	0.1

How To Read This Table: Between 1972 and 1984, employees of businesses in the Transactional Activities sector increased their share of the U.S. work force by 3.3%. Of this increase, 1.3% can be attributed to changes in this sector's productivity; 1.0% to changes in intermediate demand for Transactional Activities ("production recipe"); and 1.0% to changes in final demand for Transactional Activities (0.8% was domestic demand).

[a] Includes Federal Defense.

[b] Real Estate and Rental has been broken out of Transactional Activities due to the difficulty in estimating total output in 1984.

[c] Estimated using 1984 and 1972 Output per FTE.

NOTE: Job Shift Share = Productivity + Production Recipe and Demand + Interactive
Final Demand = Domestic Demand + Trade
Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

Table 10-8.—Productivity and Productivity Growth
(measured in 1977 dollars)

	Output per hour in 1984	Annual growth rates in productivity (in percent)		
	($1977)	1958-1984	1958-1973	1973-1984
Natural Resources	$31.50	3.11%	5.47%	0.62%
Construction	24.88	−0.74	0.74	−1.32
Manufacturing	35.24	2.02	2.61	1.32
Low Wage	23.52	2.26	2.53	2.16
Medium Wage	32.72	2.03	2.15	1.90
High Wage	48.19	1.97	3.03	0.64
Transportation and Trade	14.91	1.71	2.79	0.54
Transactional Activities	25.65	1.04	1.38	0.58
Personal Services	10.40	1.83	2.76	0.22
Social Services	11.20	0.88	1.08	0.35
Total	23.07	1.58	2.67	0.41

NOTE: Growth rates represent regressions on the log of output per hour.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, "Time Series Data Base for Input-Output Industries," June 1985, unpublished.

Low rates of productivity growth between 1973 and 1984 have been the source of considerable anguish.[7] There are no completely satisfactory explanations, though a large variety have been offered: a surge of less experienced workers from the baby boom, a decrease in R&D expenditures, dramatic shifts in oil prices that led to greater inputs of both capital and labor, and new government regulations that increased labor without increasing sales.[8] There is, of course, always the possibility that measurement techniques are inadequate.[9]

There is reason to believe that traditional patterns of productivity growth may be changing. Information technology may be able to produce productivity gains in areas never before expected. While most national productivity growth once depended on manufacturing, it is possible that productivity growth in crucial information industries may make major contributions to national productivity growth during the next two decades. All of this is obviously speculative since table 10-8 shows no significant recent growth in the productivity of service activities. The discussions of chapter 6, however, clearly showed the *potential* for real productivity growth.

There are also no acceptable techniques for measuring the productivity with which a complex production network delivers concrete services like health or education to final consumers. In periods of transformation, one of the most important products generated by businesses is learning and experience with new production paradigms. None of this learning can be gauged using short-term measures of output. The advantage of new and more flexible systems of production can only be measured by examining how they operate in a fast-moving, competitive environment over a significant period of time. Indeed, in order to achieve system-wide productivity improvements it might be necessary for some components of the network to experience productivity declines. The increased use of less-than-truckload delivery to keep inventories at a minimum is such an example. The discussions in chapter 6 provided some perspective on this issue for individual sectors.

Some evidence of the potential for changes in productivity growth can be found in statistics tracing new patterns of capital investment following the 1982 recession (see table 10-9). Capital investment in areas such as retail services averages less than

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[7] Edward F. Denison, *Accounting for Slower Productivity Growth* (Washington, DC: The Brookings Institution, 1974); and Martin N. Baily, "What Has Happened to Productivity Growth?" *Science*, vol. 234, October 1986, pp. 443-450.

[8] See Edward F. Denison, "The Interruption of Productivity Growth in the United States," *The Economic Journal*, vol. 93, March 1983; Herbert Giersch and Frank Wolter, "Towards an Explanation of the Productivity Slowdown: An Acceleration-Deceleration Hypothesis," *The Economic Journal*, vol. 93, March 1983; Wayne B. Gray, "The Impact of OSHA and EPA Regulation on Productivity," working paper, National Bureau of Economic Research, Cambridge, MA, July 1984; Assar Lindbeck, "The Recent Slowdown of Productivity Growth," *The Economic Journal*, vol. 93, March 1983; Zvi Griliches, "R&D and the Productivity Slowdown," *The American Economic Review*, vol. 70, No. 2, May 1980; Martin N. Baily and Alok K. Chakrabarti, "Innovation and Productivity in U.S. Industry," *Brookings Papers on Economic Activity*, No. 2, 1985.

[9] See Michael R. Darby, "The U.S. Productivity Slowdown: A Case of Statistical Myopia," *The American Economic Review*, vol. 74, No. 3, June 1984.

Table 10-9.—Capital Invested Per Person Engaged in Industry, 1982 and 1985
(all figures in thousands of 1982 dollars per person)

	Total capital stock			
	Gross stock per person		Net stock per person	
	1982	1985	1982	1985
Natural Resources[a]	$305	$345	$172	$187
Construction	23	17	12	9
Manufacturing	71	73	40	39
Transportation and Trade	47	46	26	26
Wholesale trade	34	41	20	26
Retail trade	22	23	13	14
Transportation	186	172	93	86
Transactional Activities				
Finance, insurance, and real estate[b]	151	161	92	98
Banking	63	80	38	48
Credit	132	137	80	85
Security	11	11	7	7
Insurance carriers	16	21	10	13
Business services	31	29	18	17
Legal serivces	9	10	5	6
Personal Services				
Auto repair services and garages	81	84	45	49
Hotels and other lodging	56	57	32	34
Motion pictures	37	37	20	20
Amusements and recreation	50	49	26	26
Social Services				
Health	11	12	7	8
Education	2	2	1	1

How To Read This Table: In 1982, net holdings of capital equipment in the natural resource industry were valued at $172,000 per person employed in that industry. By 1985, this value had grown (in real dollars) to $187,000.

[a] Includes agriculture, forestry, fisheries; mining; and electric, gas, and sanitary services.

[b] Also includes insurance agents and brokers, and services; real estate; and holding and other investment companies.

NOTE: Net capital excludes all equipment that has been fully depreciated using standard techniques. "Persons" refers to Full-Time Equivalent Employees plus self-employed persons in that industry, as defined in the National Income and Product Accounts, table 6.10.

SOURCE: J.C. Musgrove, "Fixed Reproducible Tangible Wealth in the United States, 1982-1985," p. 37; U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, August 1986; and "National Income and Product Accounts," historical diskettes.

half of that in manufacturing. Still, between 1982 and 1985, capital investment per worker grew more rapidly in many service businesses—in areas as diverse as wholesale trade, health care, automobile repair, law, and insurance—than in manufacturing.[10] Insurance companies, hospitals, and banks are now making heavy investments in information technologies and other equipment; these kinds of expenditures are beginning to result in real productivity gains.[11] Similarly, grocery stores spent nearly as much on computers and related peripheral equipment in 1982 as the entire motor vehicle industry.[12] Education was an exception to the trend; as table 10-9 shows, this industry remained close to the bottom of the list.

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[10] See James Brian Quinn, "The Impacts of Technology in the Services Sector," in Bruce R. Guile and Harvey Brooks (eds.), *Technology and Global Industry* (Washington, DC: National Academy Press, 1987), for a more detailed discussion of capital investments by services.

[11] James Brian Quinn and Christopher E. Gagon, "Will Services Follow Manufacturing Into Decline?" *Harvard Business Review*, vol. 64, No. 6, November-December 1986, p. 99.

[12] U.S. Department of Commerce, Bureau of the Census, "1982 Enterprise Statistics: General Report on Industrial Organization," October 1986, table 8, p. 292.

TRENDS IN OCCUPATIONS

The discussion thus far has followed changes in the total employment of different production sectors. Changes in the organization of work *within* these sectors have been much greater than shifts of employment *between* sectors. Again, it is useful to examine trends in job creation by occupation before attempting an explanation.

Figure 10-2 traces changes in occupations during the past century. Table 10-10 provides greater detail for the period between 1972 and 1987. There has been a consistent increase in the number of people who spend most of their day in front of office equipment or computer terminals, and a sharp decline in demand for people living by the strength of their backs or the talents of their hands. In particular:

- Farm workers have declined from about one-third of the work force at the turn of the century to less than 3 percent of the total.
- Operatives and craft workers increased from about 20 percent of all workers in 1900 to more than 35 percent at their peak in the 1950s, but their numbers have since fallen.
- There was consistent growth in clerical work between 1910 and 1980. This trend has slowed only in the last few years. The number of secretaries actually declined during the 1982/83 recession; growth since then has been moderate.[13]
- Since 1972, most job growth has been in either "administrators, executives, professionals" and their support staffs, or in sales and "other service workers"—a category that includes food handlers. Most manual jobs lost share.

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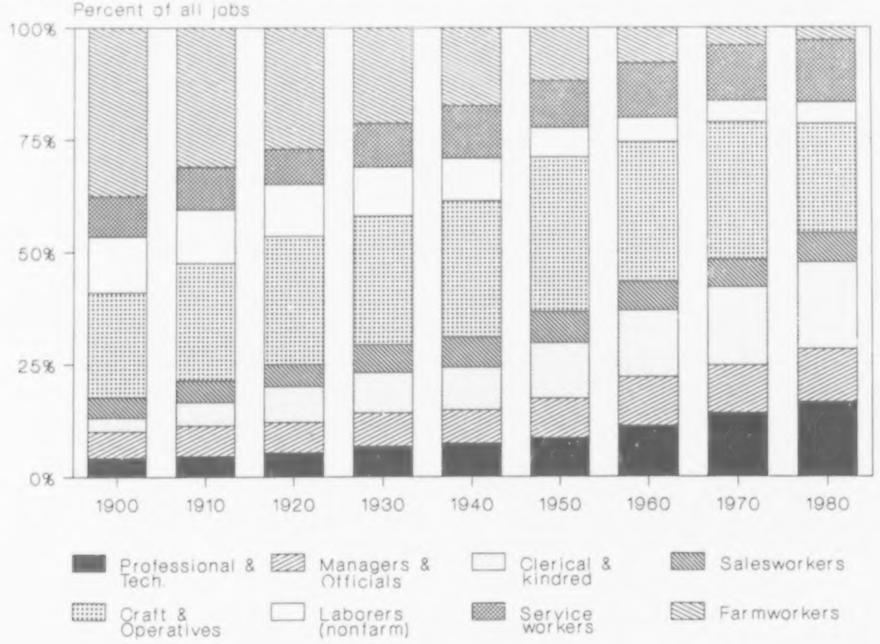
[13] H. Hartmann, R.E. Kraut, and L.A. Tilly, eds., *Computer Chips and Paper Clips* (Washington, DC: National Academy Press, 1986).

Figure 10-2.—Major Occupational Groups of the U.S. Civilian Labor Force, 1900-80



NOTE: Figures are approximate, due to changing classification systems. See sources for details.

SOURCES: U.S. Department of Commerce, Bureau of the Census, *Historical Statistics of the United States*, Part 1 (Washington, DC: U.S. Government Printing Office, 1975), Series D, p. 139; and U.S. Bureau of the Census, *Statistical Abstract of United States*, 1982-83 (103rd ed.), Washington, DC, 1982, table 648.

Table 10-10.—Job Growth by Occupation: 1972 to 1987

	Percent share of				
Occupation category	1972 jobs	1972-80 job growth	1980-86 job growth	1986 jobs	November 1986-November 1987 job growth
Managerial and professional specialty	**19.6**	**34.6**	**43.9**	**24.2**	**36.5**
Executive, administrative, and managerial	8.9	17.1	23.6	11.5	19.5
Professional specialty	10.8	17.5	20.3	12.7	17.0
Technical, sales, and administrative support	**28.8**	**39.1**	**39.1**	**31.3**	**17.7**
Technicians and related support	2.3	5.3	5.1	3.1	−1.0
Sales	10.4	13.3	23.2	12.1	−1.4
Administrative support, including clerical	16.0	20.5	10.8	16.2	20.1
Service occupations	**13.2**	**13.1**	**15.6**	**13.4**	**14.5**
Private household	1.8	−2.2	−0.8	0.9	1.2
Protective service	1.5	1.7	2.9	1.6	6.2
Other service	10.0	13.6	13.6	10.9	7.1
Precision production, craft, and repair	**12.6**	**11.2**	**11.0**	**12.2**	**4.3**
Operators, fabricators, and laborers	**21.2**	**3.7**	**−8.4**	**15.7**	**28.1**
Machine operators, assemblers, and inspectors	10.5	1.4	−9.0	7.2	9.9
Transportation and material moving	5.0	2.0	0.7	4.2	5.9
Handlers, equipment cleaners, helpers and laborers	5.7	−0.3	−0.1	4.3	12.3
Farming, forestry, and fishing	**4.7**	**−1.2**	**−1.8**	**3.1**	**−1.0**
Total employed	100.0	100.0	100.0	100.0	100.0

How to Read this Table: In 1972, 19.6 percent of all jobs were in the category "managerial and professional specialty," but 34.6 percent of job growth between 1972 and 1980 (and 43.9 percent of such growth between 1980 and 1986) occurred in this occupation category.

NOTE: See the appendix for a key to the occupations classification scheme. Numbers may not add due to rounding.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, for data since 1983. Bureau of Labor Statistics conversions used for data prior to 1983, in order to make it consistent with Occupational Employment Survey classifications shown.

The rapid growth of occupations classified as "executive, administrative, and managerial" shows the difficulty of interpreting the data. While only about 9 percent of all jobs in 1972 were placed in this category, it was responsible for more than 20 percent of all job growth between 1972 and 1986, and almost one-quarter of all such growth since 1980. Some of these new "executive" jobs result from changes in the scale and scope of enterprises, some from new technologies that affect occupational structure, some from a shift to production systems built around smaller work teams that require more managers, and some from a shift of business activity to sectors that employ more managers (e.g., fast food franchises and video rental). Some of the growth may also result from upgrading of clerical jobs to quasi-professional status, or simply from inflation of job titles. The educational level of these new managers also provides some clues. In 1980, 25 percent of all managers aged 25-34 had no more than a high school degree, 25 percent had one to three years of college, and only one in five had more than four years of college.[14]

Changes in employment by occupation and industry necessarily deal with national averages. But these numbers shed little light on the actual problems faced by the millions of workers forced to adjust to a new occupation or industry. Some of the adjustment, of course, can be accommodated by natural attrition, since the number of job openings due to death, retirement, or other reasons is several times greater than the number of openings created by employment growth[15]—while 9 million workers left the work force in 1985, 11 million new jobs were created, meaning that two million new jobs were the result of economic growth. Nevertheless, within this economy-wide picture of job replacement and creation, millions of people must face the difficulties of looking for work in an unfamiliar field.

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[14] S.E. Berryman, "Shadows in the Wings: The Next Educational Reform," Occasional Paper No. 1, National Center on Education and Employment, Teachers College, Columbia University, New York, NY, Mar. 13, 1987.

[15] U.S. Department of Labor, Bureau of Labor Statistics, *Occupational Projections and Training Data*, Bulletin 2202, Washington, DC, 1982, p. 9.

Statistics showing the number of persons forced to change jobs during the past few years leave little room for doubt about changing demands for different occupations. Manufacturing workers with three or more years on their jobs were more likely to lose their jobs than people with similar job tenure employed in other businesses.[16] Of all U.S. manufacturing employees, 15 percent lost their jobs between 1979 and 1983, and roughly 14 percent between 1981 and 1985.[17] Job loss from 1981 to 1985 was particularly great among machine operators, assemblers, and inspectors, occupations that involved the physical work of creating and assembling durable goods; this group comprised 7.2 percent of the 1986 labor force but 23 percent of all displaced workers. During 1987, absolute manufacturing employment increased somewhat while growth of sales jobs slowed.

Declining demand for manufacturing occupations meant that only 66 percent of manufacturing workers displaced between 1981 and 1985 were reemployed by January 1986.[18] Displaced professional and technical personnel were most likely to be rehired, although not necessarily in the same occupation. The shift from production to service occupations is apparent in patterns of displacement and rehiring (see table 10-11). Slightly more than half of service workers displaced had found work—virtually all in the same occupation. Over half of all machine operators, assemblers, and inspectors able to find work after being displaced were reemployed in service occupations. Similarly, 68 percent of displaced craftsmen were able to find new jobs but only 56 percent were working in their prior occupation. On average, displaced workers in blue-collar occupations spend twice as long looking for new work as white-collar professionals.[19]

Accounting for Occupational Changes

Most of the changes in occupation just described are explained by shifts in broad occupational patterns; some changes, however, defy explanation from this perspective, and must be addressed through an analysis of the underlying factors. Building on table 10-7, table 10-12 attempts to disentangle the several different effects. Changes in domestic demand, trade, production recipes, and productivity effects fail to explain most shifts in occupations. The bulk of the changes result from shifting patterns of staffing within each industry.

International trade and domestic demand have had some effect on occupations. Between 1972 and 1984, trade increased the share of jobs held by managers, professionals, sales workers, and service workers, and reduced demand for production occupations (more detail on this is found in chs. 7 and 8). Changes in domestic demand have had a similar effect. Even without the effects of trade, new patterns of consumer expenditures would have increased demand for managers, scientists, and clerical personnel, while reducing demand for precision craft workers and farm, forestry, and fishery workers.

The major limitation of the the analysis shown in table 10-12 is the assumption that productivity changes affect demand for all occupations in an industry in the same proportion. It assumes, for example, that labor productivity changes in automobile production resulted from equal growth in the productivity of the clerks, managers, and craft workers employed in that industry.

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[16] Paul O. Flaim and Ellen Seghal, "Displaced Workers of 1979-83: How Have They Fared?" *Monthly Labor Review*, vol. 108, No. 6, June 1985. The U.S. Bureau of Labor Statistics has recently published data on this subject from 1981 to 1985; see Francis W. Horvath, "The Pulse of Economic Change: Displaced Workers of 1981-85," *Monthly Labor Review*, vol. 110, No. 6, June 1987. pp. 3-12.

See also U.S. Congress, Office of Technology Assessment, *Technology and Structural Unemployment: Reemploying Displaced Adults*, OTA-ITE-250 (Washington, DC: U.S. Government Printing Office, February 1986); Robert L. Crosslin, James S. Hanna, and David W. Stevens, "Identification of Dislocated Workers Utilizing Unemployment Insurance Administration Data: Results of a Five State Analysis," National Commission for Employment Policy, RR-84-03, Washington, DC, 1984; Jeanne Prail Grodus, Paul Jarley, and Louis A. Ferman. *Plant Closings and Economic Dislocation* (Kalamazoo, MI: W.E. Upjohn Institute, 1981); and Avery F. Gordon, Paul G. Schervish, and Barry Bluestone, "The Unemployment and Reemployment Experience of Michigan Auto Workers," Boston College, Social Welfare Research Institute, August, 1985.

[17] Job loss is defined to mean a layoff from which the person was not recalled or a loss resulting from a plant closing, an employer going out of business, or "other reasons." See Michael Podgursky, "Job Displacement and Labor Market Amusement: Evidence from the Displaced Worker Survey," Department of Economics, University of Massachusetts, Amherst, MA, Jan. 19, 1986.

[18] F. Horvath, op. cit., footnote 16.

[19] Paul O. Flaim and Ellen Seghal, op. cit., footnote 16.

Table 10-11.—Reemployment of Workers Displaced Between 1981 and 1985

Occupation category	Percent reemployed	Percent employed in the same occupation	Percent employed in service occupations
Executive, administrative and managerial	72.1	43.0	0.2
Professional specialty	77.6	59.8	5.2
Technicians and related support	76.4	30.1	6.7
Sales	65.1	45.3	6.2
Administrative support (including clerical)	67.7	44.9	7.6
Service occupations	53.5	52.2	52.2
Precision production, craft and repair	68.5	55.7	7.3
Machine operators, assemblers, and inspectors	41.0	36.6	18.4
Transportation and material moving	17.1	45.9	11.2
Handlers, equipment cleaners, helpers, and laborers	68.6	26.7	10.7
Farming, forestry, and fishing	72.5	n/a	n/a

How To Read This Table: 72.1 percent of people displaced from executive, administrative, and management support occupations between 1981 and 1985 were reemployed by 1986. 43% of all people displaced from these occupations were reemployed in the same occupation. Only 0.2% were reemployed in service businesses.

SOURCE: Francis W. Horvath, "The Pulse of Economic Change: Displaced Workers of 1981-85," *Monthly Labor Review* vol. 110, No. 6, June 1987, pp. 3-12.

Table 10-13 provides some insight into patterns of occupational productivity *within* business categories. Between 1983 and 1986, for example, the number of executives and managers grew faster than the overall employment in every industry except wholesale trade, making it the fastest growing occupation over this time period. Job growth for professional specialists (engineers, scientists, teachers, doctors, nurses, lawyers, etc.) nearly equalled U.S. average job growth, but this occupation had disproportionately high gains in the agriculture, manufacturing, and public utilities industries. The two slowest growing occupations over this time period were operators, assemblers & inspectors, and service workers (food service employees, private household workers, and custodians). The rapid growth of transactional businesses, most notably in the other services and the FIRE (finance, insurance, and real estate) industries, which had 7 percent annual growth in demand for managers, has fueled total national job growth in this occupation.

The last few years have also seen wide divergences in hiring practices for administrative support and clerical personnel. Manufacturing, mining, and transportation, as well as the finance, insurance, and real estate industries, all added jobs in this occupation category at a slower rate than average industry job growth. In contrast, the professional service and other service industries, including health and education, added clerical jobs more rapidly than jobs in other areas. Professional service employers are using clerical workers in quasi-professional jobs by substituting computers for functions like routine underwriting, and are eliminating many routine data entry functions in the process. Hospitals and other professional health organizations are using increasing numbers of clerical employees to manage what has become a complex, information-intensive enterprise. Management of health facilities has come to be dominated by professional specialists, bringing with them a growing demand for expertise in record keeping and billing as well as patient care.

These statistics describe massive changes in the way the United States is using different skills to produce goods and services demanded by the American public. They have little explanatory power. Understanding the changes requires a deeper comprehension of the way people are used in new production networks. This is the task of chapter 12.

Table 10-12.—Change in Occupational Job Share from 1972 to 1984 for Various Factors (in percent)

	Executive, administrative, and managerial	Professional specialty	Technicians and related support	Sales	Administrative support (including clerical)	Service occupations	Precision production, craft and repair	Machine operators, assemblers, and inspectors	Transportation and material moving	Handlers, equipment cleaners, helpers, and laborers	Farming, forestry, and fishing
Job Shift Share	2.1	1.9	0.7	1.8	−0.1	0.3	−0.2	−2.9	−0.8	−1.5	−1.3
Productivity . . .	0.2	0.5	0.1	−0.2	0.5	0.2	−0.3	−0.8	−0.1	−0.1	0.2
Production Recipe & Demand	0.2	−0.2	−0.0	0.9	0.5	0.2	−0.6	−0.6	0.1	−0.2	−0.3
Production Recipe . . .	0.1	−0.3	−0.0	0.5	0.1	−0.0	−0.1	−0.2	0.1	−0.0	−0.1
Final Demand	0.1	0.2	0.0	0.3	0.4	0.2	−0.5	−0.4	−0.0	−0.2	−0.3
Domestic Demand.	0.1	0.1	0.0	0.2	0.3	0.1	−0.4	−0.0	−0.0	−0.1	−0.3
Trade	0.1	0.1	0.0	0.2	0.1	0.2	−0.1	−0.4	0.0	−0.1	−0.0
Staffing Patterns	1.7	1.6	0.6	1.1	−1.1	−0.1	0.7	−1.4	−0.8	−1.2	−1.1

How To Read This Table: Between 1972 and 1984, the share of all jobs classified as executive, administrative, and managerial increased by 2.1 percentage points. Of this change, only 0.2 percentage points could be explained by changes in production or consumption recipes and −2 percentage points could be explained by changes in the productivity of different business types. The bulk of the change (1.79%) was attributable to changing staffing patterns.

NOTES: Job Shift Share = Productivity + Production Recipe and Demand + Staffing Patterns. Final Demand = Domestic Demand + Trade. Numbers may not add due to rounding. See the appendix for a key to the occupations classification scheme.

SOURCE: Office of Technology Assessment, 1988.

Table 10-13.—Growth Rates in Employment by Occupation and Industry

(average annual percentage increase, 1983-1986)

	Total employees	Executive, administrative, and managerial	Professional specialty	Technicians and related support	Sales	Administrative support (including clerical)	Service occupations	Precision production, craft and repair	Machine operators, assemblers, and inspectors	Transportation and material moving	Handlers, equipment cleaners, helpers, and laborers	Farming, forestry, and fishing
Agriculture	−2.2	12.1	5.1	5.3	0.0	1.3	−4.4	−5.2	6.9	0.0	4.3	−2.9
Mining	−1.5	0.2	−2.3	−1.8	9.1	−5.2	−11.2	−3.7	−4.5	2.4	7.7	0.0
Construction	5.8	8.5	2.3	12.9	5.2	3.8	−5.7	6.2	−1.4	1.2	7.2	−4.1
Manufacturing	1.7	4.5	3.8	2.4	2.8	0.6	0.1	1.8	0.5	−1.4	4.7	−6.1
Transportation and public utilities	3.1	7.3	5.0	1.5	10.1	2.4	2.1	0.8	−0.9	3.1	1.9	−7.2
Trade	2.6	2.1	1.9	8.2	3.0	2.0	1.8	1.7	2.4	4.7	2.8	10.5
Wholesale	0.8	−2.8	−1.6	3.5	1.7	−0.1	−7.8	−0.9	−1.0	3.6	3.7	6.3
Retail	3.0	4.0	2.9	12.4	3.3	3.3	1.9	2.4	5.5	5.8	2.6	10.7
FIRE[a]	4.4	6.5	4.4	6.0	5.6	3.0	0.8	3.5	−4.7	9.1	3.2	−3.6
Services	3.4	7.0	2.5	3.1	9.6	4.1	2.4	2.1	3.2	7.4	6.2	0.7
Private household	−0.3	0.0	−3.1	−38.0	0.0	2.9	18.4	−3.1	0.0	−17.0	−14.0	−4.5
Other	3.5	7.0	2.5	3.4	9.6	4.1	2.3	2.1	3.1	7.6	8.2	2.8
Professonal services	2.3	5.9	2.0	2.6	9.3	3.3	0.1	−1.7	2.9	5.6	6.6	2.8
Public administration	2.7	3.7	3.5	4.9	0.0	1.9	2.8	−0.1	−3.9	7.4	−1.2	3.9
Total	2.8	5.5	2.5	3.1	3.7	3.0	1.8	2.5	1.0	3.5	3.9	−1.9

How to Read this Table: Between 1983 and 1986, employment in agriculture fell at an average rate of −2.2 percent per year, while total U.S. employment grew 2.8 percent per year. In spite of the declining employment in agriculture, the number of executives and managers employed in agriculture increased by 12.1 percent per year. Taking all sectors together, executives and managers increased at an average rate of 5.5 percent per year.

[a] FIRE = Finance, insurance, and real estate.

NOTE: See the appendix for a key to the occupations classification scheme.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, various issues.

Chapter 11

Matching People to Jobs

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Chapter 11

Matching People to Jobs

Few jobs will remain unaffected as structural change in the U.S. economy reshapes demand for skills, and as changes in demographics and education reshape supplies of skills and experience. Managers, physicians, laborers, clerks, sales people, and many others will find their jobs redefined. They will face changes in their power to command wages, in the stability of their positions, in the safety and the stress of their work, and in the texture of their daily working life. There will be new opportunities for pride and enjoyment in the workplace, and new opportunities for frustration and alienation.

Two things must happen to increase the fraction of people holding jobs that pay well and are rewarding in other ways: first, people looking for work must have the education and experience needed to take such positions; and second, production networks must change in ways that generate large numbers of such positions. Both are necessary for constructive change, but neither is sufficient. Increased supplies of well qualified people do not guarantee that the economy will generate good jobs. Technology capable of generating interesting employment opportunities can also be used to exaggerate the differences between rewarding and unrewarding jobs.

Previous chapters demonstrated that increasing demand for flexibility is a critical part of structural change in a period when trade and deregulation have heightened competitive challenges. This flexibility can only be achieved if management strategies are redefined to exploit the opportunities created by innovation. The point at issue is the way business networks will achieve the needed flexibility. Will flexibility be gained through production systems designed under the assumption that most employees will have few skills and little personal interest in the product or service delivered? Or will flexibility be achieved instead by building the capacity to adapt quickly and effectively with individuals and teams—creating value-added from the skill and commitment of all individuals involved?

It is simply too early to prove which of these strategies is more efficient with statistically convincing data. There is every reason to believe, however, that a production system based on skilled employees taking interest and pride in what they do is more likely to prosper in a period of transformation and heavy competition than one built on the presumption that good ideas come only from an elite. The second alternative also carries high social costs. It is reasonable to ask whether a democratic society can or will tolerate sharply growing disparity between elite and less privileged workers. The evidence presented throughout this discussion suggests that there is nothing inevitable about growing inequality in wages or job quality. Nor is there any guarantee that technology will be used to decrease inequality.

Flexibility, of course, is important for employees as well as for businesses. Working parents need flexibility to combine child raising with employment. Students and the elderly often prefer flexible schedules. Ambitious employees may want the flexibility to combine work with training and the freedom to move within and among companies. The critical question is whether strategies to achieve flexibility can work to serve both employer and employee interests.

One obvious effect of new production systems is their ability to affect the bargaining power of different groups. The pay commanded by different occupations is determined by a baffling mix of market forces and social values. Changes in both factors seem likely to reshape the links between pay and skill during the next two decades. Paying the average employee in the "Security and Commodity Broker" industry 3.8 times more than the average employee in education may well be a rational allocation of national economic assets. It is also possible that the rules that led to this and other large inequalities in pay are based in part on factors that could change as the economy is reshaped.

The factors shaping demand for work of different kinds are complicated by the fact that work can be an end in itself as well as a means to an end. Most people do not simply work until the "marginal unpleasantness is not worth the marginal wage,"[1] nor do most see work as merely receiving payment for an unenjoyable task. Pay cannot substitute for the triumph an inventor senses when an idea clicks, the delight a teacher takes on opening a mind to a new world, the pride a craftsman takes in a well built house, or the satisfaction a nurse or physician can find in delivering a baby or saving a life. The extent to which society expects such experiences or responsibilities to substitute for pay, of course, can change. For example, women are less likely to accept non-cash rewards in lieu of wages for traditionally "female" tasks, such as nursing and elementary school teaching, now that other opportunities are opening for their skills.

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[1] Tibor Scitovsky, *The Joyless Economy* (London, England: Oxford University Press, 1976), p. 90.

Many of the forces driving inequality will weaken over the next several decades, but they could well be replaced by others. The gap separating male and female wages, for example, has declined; this results in part from the growing number of women needing incomes and a rapid decline of high-paid, traditionally male jobs.

It is likely that incomes will depend increasingly on education and other formal credentials. This could be true because formal training has practical value in adding to a person's productivity and because education serves as a kind of hazing process, allowing those that emerge first priority in getting good jobs. Credentials provide a manager with an easy tool for selection when the characteristics needed are difficult to define with precision. As a result, credentials may gain in value as more jobs fall into nontraditional categories.

Inequality in educational levels may lead increasingly to inequality in incomes. Most of the people entering the work force during the next two decades will be minorities and other groups that have often been poorly served by the Nation's educational system. Older workers displaced by new technology may lack the basic literacy and mathematical skills demanded by employers with expanding job opportunities.

The relative bargaining power of workers and management can be affected by changes in production systems. When a premium is placed on adaptability, the premium paid for seniority in a narrow task or for specialized skills must weaken. But people well adapted to the needs of a rapidly changing economic environment have found it difficult to translate their contribution to high wages because they lack a monopoly on any particular skill. If nothing else, the task of rewarding individual contributions to a business becomes much less mechanical.

This chapter enters these issues in the following order. It first addresses changes in U.S. labor supplies, examining both the number and kind of workers entering the work force. It then explores four aspects of the quality of the jobs being produced:

1. changes the demand for skills,
2. changes in wages and non-wage benefits,
3. changes in the flexibility and security of jobs, and
4. changes in job quality (measured in terms of both safety and the extent to which jobs match an individual's expectation of work as an act of self-fulfillment).

LABOR SUPPLY: THE SIZE AND COMPOSITION OF THE U.S. WORK FORCE

During the next two decades, the U.S. labor force is likely to grow much more slowly than it has in the recent past. The average worker will be older, more likely to be female, and less likely to be a non-hispanic white.

The labor force grew 3 percent per year during the early 1970s as the baby boom generation entered the work force and as women acquired jobs in increasing numbers. Growth rates declined sharply as the last of the baby boomers came of age. While the number of workers aged 45-55 is expected to double during the next two decades, the number of new entrants will decline rapidly. The proportion of workers under the age of 24 could fall from approximately 30 percent in 1985 to 16 or 17 percent by 2005. Overall annual growth in the work force is expected to reach about 1 percent by the early 1990s;[2] growth could approach zero by 2020, depending on future rates of immigration.

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[2] Janet L. Norwood (Commissioner of Labor Statistics, U.S. Department of Labor), "The Future of Employment," address to the Institute of Industrial Relations, University of California at Los Angeles, Oct. 18, 1986.

Women now constitute nearly two-thirds of all labor force growth, a share that is expected to continue through the end of the century.[3] Younger women today are participating in the work force at a rate approaching that of their male counterparts. Between 1976 and 1986, women identifying themselves as "housekeepers" fell from 41 to 32 percent (see table 11-1). More women are looking for full- and part-time work, although a growing fraction of part-time work is involuntary.

In a sharp break from tradition, women are remaining in the work force even when they have children. Women born before 1945 tended to leave their jobs to raise children (see figure 11-1). In 1984, over two-thirds of women with children aged 6 to 17 were in the labor force—more than double the rate of 1950.[4]

While the number of working women is increasing, the percentage of men at work is actually below 1966 levels (again see table 11-1). In 1960, men between the ages of 55 and 64 were about as likely to be in the work force as their younger colleagues, but their participation rate has fallen steadily and is now below 70 percent (see figure 11-2). If this 20-year trend continues, only half of the men aged 55 to 64 will be working by the turn of the century. Participation for men over the age of 65 has fallen even more sharply, from 45 percent in 1950 to about 15 percent in 1985.

Declining participation rates among older men can be attributed to two main factors. First, some men are leaving the work force because early retirement maximizes returns on a pension.[5] Second, many older men work in "declining" occupations and industries, and face a choice of retiring early, remaining employed by accepting a low-skill, low-wage po-

Table 11-1.—Employment Status of Noninstitutionalized Adults Age 16 and Over (in percent)

Category	1966	1976	1981	1986
Men:				
Employed	81.5%	75.1%	72.8%	73.6%
Full time	77.2	69.4	67.0	66.9
Voluntary part time	2.9	3.6	3.6	3.9
Involuntary part time[a]	1.3	2.1	2.2	2.8
Looking for work (unemployed)	2.1	4.7	4.9	4.4
Looking for full time	1.9	4.4	4.6	4.0
Looking for part time	0.2	0.4	0.3	0.4
Not in labor force	16.5	20.2	22.3	22.0
Housekeeping[b]	N.A.	0.3	0.4	0.6
Education[b]	N.A.	1.8	1.5	1.9
Other	N.A.	18.1	20.4	19.5
Total	100.0	100.0	100.0	100.0
Women:				
Employed	38.6	36.8	49.1	53.0
Full time	30.0	27.5	36.8	39.5
Voluntary part time	7.6	7.9	10.0	10.5
Involuntary part time[a]	1.1	1.4	2.4	3.1
Looking for work (unemployed)	1.5	3.5	4.3	3.5
Looking for full time	1.2	2.8	3.7	2.7
Looking for part time	0.3	0.7	0.6	0.7
Not in labor force	59.9	59.7	46.6	43.5
Housekeeping[b]	N.A.	41.2	34.5	31.8
Education[b]	N.A.	1.8	1.7	1.8
Other	N.A.	16.7	10.4	9.9
Total	100.0	100.0	100.0	100.0

NA = Not available.

[a] Assumes that involuntary part time for age 18-24 divided by age in same proportion in years 1966 to 1981 as in 1986.

[b] For years 1966 and 1976, assumes that persons in education and housekeeping aged 16-20 are same proportion as total.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Handbook of Labor Statistics 1983*, Bulletin 2175; *Employment and Earnings*, vol. 33, No. 11, Review, November 1986.

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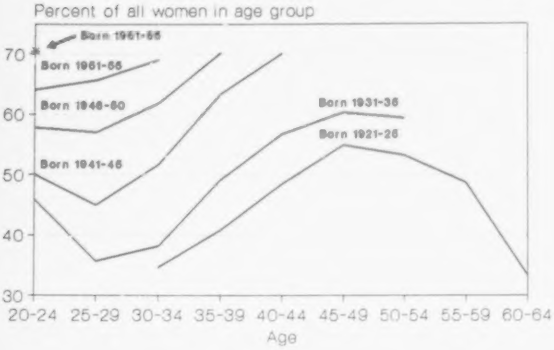
[3] Ronald E. Kutscher, "Projections 2000—Overview and Implications of the Projections to 2000," *Monthly Labor Review*, vol. 110, No. 9, September 1987, p. 4.

[4] U.S. Department of Labor, Bureau of Labor Statistics, *Handbook of Labor Statistics 1983*, Bulletin 2175, Washington, DC, 1983; and *Employment and Earnings*, vol. 33, No. 11, November 1986.

[5] U.S. Department of Labor, Bureau of Labor Statistics, cited in "Demographic Forecasts," *American Demographics*, vol. 8, No. 3, March 1986, p. 58.

Figure 11-1.-Work Force Participation of Women Born in Different Years

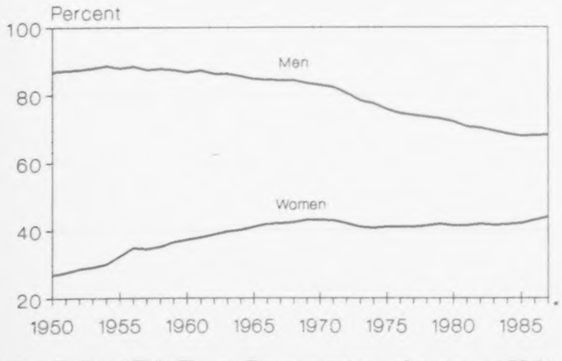


How To Read This Figure: 46% of women born between 1931 and 1935 were working when they were between the ages of 20 and 24. By the time they reached age 25-29, however, only 36% were working (many were now at home with young children). This same group of women, however, returned to the work force by the time they were 45-49 years of age, when over 60% were working.

People are defined to be participating in the work force if: (1) they did any paid work, (2) they made specific efforts to find employment sometime during the prior four weeks, (3) they were waiting to be recalled to a job from which they had been laid off, or (4) they were waiting to report to a new job within 30 days.

SOURCE: Ray Marshall and Beth Paulin, "Employment and Earnings of Women: A Historical Perspective," *Working Women: Past, Present, and Future*, Industrial Relations Research Series (Washington, DC: Bureau of National Affairs, 1987).

Figure 11-2.-Participation Rates for Workers Aged 55-64 (percent employed or actively looking for work)



How To Read This Figure: The percentage of men aged 55-64 participating in the work force declined from about 90% in 1950 to about 50% in 1987 (see figure 11-1 for definition of "participation").

*November 1987.

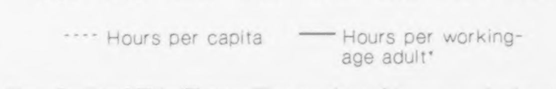
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, various issues.

sition, or receiving extensive and often costly vocational training in order to keep a job of the same stature.[6]

The increase in early retirements, however, may be a temporary phenomenon—an artifact of structural change and not a long-term trend. In the future, workers may not have retirement benefits that allow or encourage early retirement. Baby boomers may not want to retire if they are healthier and if their jobs are more rewarding and a more integral part of their social lives.[7]

The effects of earlier retirement and lower numbers of working hours per adult appears to have more than offset the increase in the number of working women. Figure 11-3 indicates that the number of hours worked per working age adult has actually declined during the past few years. On the other hand, the number of hours worked per American

Figure 11-3.-Recent Declines in Hours Worked Per Working-Age Adult* and Increases in Hours Worked Per Capita



How To Read This Figure: The number of hours worked per capita in 1986 was 14% higher than in 1965 (i.e., the index went from 1.00 to 1.14 during the period). The number of hours worked per working age adult (defined to be all people between the ages of 16 and 65 that are not in jails, nursing homes, or other institutions), however, declined by about 4% (the index fell from 1.00 to 0.96).

*Noninstitutional population aged 16 to 65.

SOURCES: U.S. Department of Labor, Bureau of Labor Statistics, *Monthly Labor Review*, various issues; and U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.11.

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[6] See U.S. Congress, Office of Technology Assessment, *Technology and Aging in America*, OTA-BA-264 (Washington, DC: U.S. Government Printing Office, June 1985), pp. 27-29.

[7] Terry Stephenson Supple, "The Coming Labor Shortage," *American Demographics*, vol. 8, No. 9, September 1986, p. 35.

(counting the entire population) has increased as the baby boom has entered the work force. Higher gross national product (GNP) per capita has therefore been achieved in part by simply adding more people to the work force.

The racial mix of American workers is also changing rapidly. A majority of the people entering the U.S. labor force during the next few decades will be black, Hispanic, or Asian (see table 11-2). Blacks represented 9.2 percent of the work force in 1970, but are expected to account for 11.8 percent in the year 2000. The U.S. Bureau of Labor Statistics (BLS) projects that by the early 1990s more than 17 percent of all new entrants to the labor force will be black. Growth rates for Asian and Hispanic workers are more difficult to anticipate, since the rate depends on the extent to which illegal immigration from Asia and Central and South America is contained. Hispanics are expected to grow from 7 percent of the work force in 1986 to at least 10 percent in 2000.[8]

Table 11-3 summarizes three sets of assumptions about participation rates for the year 2005:

1. The first case assumes simply that 1986 participation rates remain unchanged.
2. The second case assumes that participation rates for women are at least 90 percent of the rate of men in each age group (a trend established by women born in 1962/63); it also assumes that participation rates of older workers decline, following 20-year trends.
3. In the third case, it is assumed that men over the age of 55 will have approximately the same participation rate as they did in 1975, while older women participate at 90 percent of male rates.

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[8] R.E. Kutscher, op. cit., footnote 3, p. 4.

Table 11-2.—Racial Composition of the U.S. Work Force 1986-2000

	Percent of the work force in 1986	Percent of the work force in 2000	Percent of growth in work force between 1986 and 2000
Black	10.8	11.8	17.4
Asian[a]	2.8	4.1	11.4
Hispanic[b]	6.9	10.2	28.7
White	86.4	84.1	71.2

NOTE: Totals exceed 100 percent because hispanics are also counted in other races.
[a] Includes native Americans, Alaskan natives, Pacific islanders.
[b] Persons of Hispanic origin may be of any race.

SOURCE: Ronald E. Kutscher, "Projections 2000—Overview and Implications of the Projections to 2000," *Monthly Labor Review*, vol. 110, No. 9, September 1987, p. 4.

Table 11-3.—Work Force Participation Rates

	Age range:							
	16-17	18-19	20-24	25-34	35-44	45-54	55-64	65+
Men:								
Case #1: 1986 Levels	0.41	0.66	0.85	0.94	0.95	0.91	0.68	0.16
Case #2: 2005 Trend	0.41	0.66	0.85	0.94	0.95	0.91	0.50	0.03
Case #3: 2005 Alternative	0.41	0.60	0.80	0.94	0.95	0.91	0.75	0.20
Women:								
Case #1: 1986 Levels	0.42	0.60	0.73	0.73	0.75	0.67	0.43	0.08
Case #2: 2005 Trend	0.41	0.60	0.77	0.85	0.86	0.82	0.42	0.05
Case #3: 2005 Alternative	0.41	0.60	0.77	0.85	0.86	0.82	0.68	0.18

SOURCE: Office of Technology Assessment, 1988 (see text for details).

CHANGES IN THE QUALITY OF JOBS PRODUCED

An analysis of the match between jobs desired and jobs available must confront the vexing problem of defining a "good" job. Clearly, the answer to this question is as varied as the U.S. labor force itself. The following discussion will examine four aspects of the issue:

1. How do the changes in production networks translate into changes in demand for different

kinds of skill?

2. How well are different skills paid? How can these differences be explained?
3. How much flexibility does a job offer to those that desire it?
4. How well does a job match an individual's expectation of work as an act of self-fulfillment? Is the job dangerous?

Technology and Skill

The problem of estimating the impact of new production recipes on skills and work life is not new. Hesiod worried about the effects of structural change on Greek workers in 800 B.C.[9] Literature since the industrial revolution documents concern about the dehumanizing effects of automation, the alienation of worker from employer, and the increasingly vague connection between what a worker does during the day and a product of real social value (see box 11-A).

One question remains at the core of these discussions: precisely what do humans do better than machines? The question is presented in different ways as each new wave of innovation sweeps old patterns of production aside. Information technology has given it an entirely new twist. Machines are not only able to beat the fabled John Henry at steel driving, and weave more skillfully than Ned Ludd, they are now capable of seeing, touching, remembering billions of facts, and even undertaking elementary forms of reasoning.

In a period of transformation, basic questions need to be asked about where people can fit in as machines substitute for labor and skill. There is always one easy answer: people will be used instead of machines when they are less expensive. Anyone holding a job on this basis is obviously vulnerable. There are better answers.

Technology can enhance the human elements of work by automating tasks that have forced men and women to mimic machines. As chronicled in this volume (particularly in chs. 6 and 12), the technology now entering the U.S. economy has the potential to reduce the mechanical aspects of most work, allowing greater use of human imagination and greater opportunity for personal communication. Information technology can remove barriers between conception and execution in ways that expand the time devoted to developing and testing the products of imagination. The ratios of authors to typesetters, architects to draftsmen, clothing designers to textile and apparel workers, and even of individual tutoring to repetitive recitation of lectures, can all increase. Medical personnel can spend more time talking with patients, and less time struggling with routine forms or counting cells through microscopes. Technology can allow sales personnel to spend more time with customers and clients so that they can more fully understand a customer's idiosyncratic tastes and desires. Innovation also makes it possible to tailor products and services to fit—benefiting both the customer and the producer while creating a more satisfying link between work and the final product.

It is obviously possible that the new technology can be used to make jobs more and not less mechanical. Information equipment could be used to create rigidly authoritarian management styles that force employees into narrowly defined tasks with little room for individual expression. In general, however, attempts to organize production in this way have not met with success.

Some jobs seem virtually unaffected by changes sweeping the rest of the economy. The jobs of farm workers, house cleaners, and nursing assistants require menial tasks that are difficult to replace with technology. Many such jobs involve sub-standard working conditions. Most are held by minorities and women.

The New Production Networks

The old debates over the links connecting technology and skill plainly need redefinition. The impact of complex production networks on jobs during the past few decades defies convenient characterization. It is not enough to ask whether technology degrades or upgrades a specific task (such as machining or typing). Rather, it is necessary to measure the effect of change on the entire network of employment that combines to deliver an amenity. These networks now combine a baffling collection of jobs. Jobs lost on the factory floor may be replaced by information-handling positions in other business sectors in other States.

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[9] Hesiod, *Works and Days.*

What is the net effect of a shift from an economy dominated by machinists and farmers to one dominated by middle managers, para-professionals, sales clerks, and information processors (as outlined in ch. 10)? It is likely, for example, that wages for "managerial" occupations will be reduced as growing numbers of people take jobs classified as management. However hard the Bureau of Labor Statis-

Box 11-A.—The Debate on Technology and Skills: Selected Views

Adam Smith, who provided the first clear example of the advantages of labor specialization, expressed clear reservations about the effects of such a development taken to the extreme:

> The man whose whole life is spent in performing a few simple operations, of which the effects are perhaps always the same, or very nearly the same, has no occasion to exert his understanding or to exercise his invention in finding out expedients for removing difficulties which never occur. He naturally loses, therefore, the habit of such exertion, and generally becomes as stupid and ignorant as it is possible for a human creature to become.[1]

The management specialist Fredrick Taylor attempted to apply the principles of good engineering design in machinery to the design of jobs. The central idea was to disconnect conception from execution, dividing tasks into discreet, highly specialized functions. Management would specify the correct way for an employee to move and act in the performance of these functions much as it would design specifications for a piece of equipment. The employee would be evaluated entirely in terms of the effectiveness of such actions, and would not be expected to understand the integrated operation of the production process.

Daniel Bell, and others writing in the 1960s and early 1970s, argued that the share of unskilled workers was diminishing throughout the economy, being replaced by substantial numbers of knowledge-based employment opportunities.[2] Several empirical studies seemed to confirm this.[3] One 1963 analysis of automation in coal mining concluded that:

> . . . extreme division of labor characteristics of previous stages of industrial development would be replaced by situations with fewer and less specialized work roles. The jobs of the future would require multi-skilling and share responsibility, possibly giving rise to composite or autonomous work groups with little or no internal supervision.[4]

Concern about alienation of the labor force has taken a somewhat different turn with each new wave of automation. In 1958, Charles Bright looked at technologies then entering the factory, and concluded that "automation had reduced the skill requirements of the operating work force and occasionally of the entire factory force, including the maintenance organization."[5] P.B. Doeringer and Michael Piore described the emergence of a "dual labor force"—one split between routine, low skilled jobs and an elite set of jobs—with reduced opportunities for moving from one area to the other.[6] David Noble reviewed the history of machine tools to prove a similar point.[7] While many of these works take a starkly ideological perspective, aspects of the thesis do find broad support. Abernathy, Clark, and Kantrow, writing about the "single, dominant paradigm for production" in the United States, find:

> If skills can be progressively built into machines, then workers need not be especially skilled themselves . . .
> . . . [G]ear up for long production runs, buffer yourself with enough inventory to keep the lines moving, inspect for defects—if at all—at the end of those lines, treat workers primarily as a reservoir of costs that can be bled out under pressure as the need arises, and you will boost your market share, your profits, your stockholder's good disposition, your bond ratings, your own compensation, and the Nation's industrial health.[8]

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[1] *The Wealth of Nations, 1776* (London: Everyman's Library, J.M. Dent & Sons Ltd., 1947), vol. II, p. 278.

[2] Daniel Bell, *The Coming of Post-Industrial Society* (New York: Basic Books, 1973); C. Kerr, J.T. Dunlop, F.H. Garbison, and C.A. Myers, *Industrialism and Industrial Man* (Cambridge, MA: Harvard University Press, 1960).

[3] R. Blauner, *Alienation and Freedom* (Chicago, IL: University of Chicago Press, 1964); C.R. Walker, *Toward the Automatic Factory* (Westport, CT: Greenwood Press, 1957); J. Woodward, *Industrial Organization: Theory and Practice* (London, England: Oxford University Press, 1965).

[4] E.L. Trist and K.W. Bamforth, "Some Social and Psychological Consequences of the Longwall Method of Coal Getting: An Examination of the Psychological Situation and Defenses of a Work Group in Relation to the Social Structure and Technological Content of the Work System," *Human Relations*, vol. 4, No. 1, 1951, pp. 3-38.

[5] J.R. Bright, "Does Automation Raise Skill Requirements?" *Harvard Business Review*, vol. 36, No. 4, July/August 1958, p. 86.

[6] P.B. Doeringer and M.J. Piore, *Internal Labor Markets and Manpower Analysis* (Lexington, MA: Heath-Lexington Books, 1971).

[7] David F. Noble, *Forces of Production: A Social History of Industrial Automation* (New York, NY: A.A. Knopf, 1984); *America By Design: Science, Technology, and the Rise of Corporate Capitalism* (New York, NY: A.A. Knopf, 1977).

[8] W. Abernathy, K. Clark, and A. Kantrow, *Industrial Renaissance: Producing a Competitive Future for America* (New York, NY: Basic Books, 1983).

tics works to ensure consistency of definitions, statistics give an imperfect view of the changes taking place. Many changes can only be understood by examining patterns of job change in individual sectors, as undertaken in chapter 12.

Perhaps the most striking change is that occupations now held by people with college degrees are growing comparatively quickly. College graduates held 13.2 percent of all jobs in 1967 but 25.3 percent of all jobs in 1987 (see table 11-4). About half of all new jobs were filled by college graduates during these two decades.

The way jobs are created, and the pay that can be commanded by these jobs, depends heavily on management discretion. Two factors appear to have a major impact on the way production strategies translate into demand for skills, and into the bargaining power of employees offering different skills: the extent to which businesses, or networks of businesses, are managed as authoritarian hierarchies; and the extent to which workers can be easily substituted for each other.

The Rise and Fall of Hierarchies.—Will new business networks provide more or less freedom than the ones they replace? Will they provide workers with more independence and therefore more opportunities for taking pride in what they accomplish at work, or will they result in rigidly hierarchical management structures in which individual employees find themselves meticulously monitored in the way they undertake ever more specialized assignments?[10] The studies of business networks in chapters 6 and 12 provide no clear guidance. There appears to be no necessary link between production technology and the kinds of jobs created. Both manufacturing and office work can be upgraded or sharply downgraded as the result of new equipment. Clerical office workers can be upgraded to take on new responsibilities—becoming "parapublishers," "paralibrarians," and "paramanagers"—or their jobs can be reduced to mindless data entry.[11] Production workers can be made a part of teams expected to move quickly from a design to a new product, or they can be reduced to machine tenders.

It is difficult to demonstrate which management strategy will prove most effective in different circumstances. On the other hand, there is a growing body of anecdotal evidence supporting the view that the new generation of automation works well in office and manufacturing environments only when people expected to work with the equipment have a role in modifying the system.[12] It now appears that more of the next generation's job opportunities will be built around ambiguous situations, as opposed to those that are routine. Insurance underwriters will see more complex and unusual cases. Manufacturing operatives may need to intervene in the production process only when something breaks, or when a control program needs to be redesigned around a new part. It may be possible to build such a system using unskilled personnel with narrow task assignments operating under rigid hierarchical control. However, it is difficult to conceive that this kind of arrangement—or one that prevents the organization of a team of people who expect to work together for some time—could work well under dynamic conditions.

Company interest in employee roles is frequently credited for the success of the GM/Toyota plant in Fremont, CA.[13] Xerox, Kodak, Hewlett Packard, and several other firms have shifted production to teams including engineering marketing, design, *and* production. There is a growing belief that large plants

Table 11-4.—Education Levels of the U.S. Work Force, 1967-87 (in percent, age 25-64)

	Labor force share in:		
Education level	1967	1979	1987
Less than 4 years of high school	41.1	21.9	14.9
4 years of high school	35.2	39.6	40.2
1 to 3 years of college	10.6	17.3	19.7
4 years of college or more	13.2	21.3	25.3
Total (ages 25-64)	100.0	100.0	100.0

NOTE: Percentages calculated for March of years indicated.

SOURCE: Wayne J. Howe, "Education and Demographics: How Do They Affect Unemployment Rates?" *Monthly Labor Review*, vol. 111, No. 1, January 1988, p. 4.

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[10] See Barbara Baran and Carol Parsons, "Technology and Skill," Berkeley Roundtable on International Economics, University of California, Berkeley, CA, January 1986.

[11] Larry Hirschorn, "Office Automation and the Entry Level Job. A Concept Paper," Management and Behavioral Science Center, Wharton School of Business, University of Pennsylvania, Philadelphia, PA, no date; and R. Howard, *Brave New Workplace* (New York, NY: Viking Press, 1985).

[12] M.A. Maidique and R.M. Hayes, "The Art of High-Technology Management," *Sloane Management Review*, vol. 25, winter 1984, pp. 17-21.

[13] See Richard Corrigan, "GM-Toyota-Deal Symbolizes the Trend Toward an International Car Market," *National Journal*, vol. 15, No. 23, June 4, 1983, pp. 1156-1161.

may suffer diseconomies because of the distance between different kinds of workers inherent in a large scale. A senior vice president of General Electric's aircraft engines division was recently quoted as saying that management can be closer to workers if plants are limited to between 600 and 1,500 people.[14] Nearly two-thirds of the 830-person work force in a Westinghouse Furniture Systems plant in Grand Rapids, MI is involved in both product design and business strategy. The teamwork seems to have paid off: plant productivity—measured by constant dollar sales per employee—rose 74 percent between 1983 and 1986.[15] Unfortunately, the integration of job design with equipment design is probably an exception and not the rule. Interviews with 196 organizations found little planning in reorganization of offices around new technology.[16]

Efforts to introduce mass production models in clerical activities have met with mixed success. It was once thought that large "typing pools" and segregated "back office" activities would represent the future of clerical work. While no national statistics are available, anecdotal evidence suggests that instead of being isolated in "electronic sweatshops," clerical staffs are being more closely integrated into the substantive work of businesses in ways that make these employees less and not more mechanical. The insurance industry, discussed in greater detail in chapter 12, provides examples of businesses which have reintegrated clerical and professional tasks in both function and office location. Surveys conducted by Honeywell, Minolta Corp., and Professional Secretaries International have shown that 70 to 90 percent of secretaries believe automation makes their tasks go faster, and frees time for more interesting and challenging work.[17] A survey by the National Association of Working Women (9-to-5) found that work with new office technology was both more interesting and enjoyable (68 percent) and less stressful and pressured (54 percent).[18]

The integration of management with other workers is a necessity in comparatively small establishments whether or not they are a part of larger firms. Travelers Corp., a Hartford, CT insurance firm, is finding that after their organization had responded to new technology-based sales and underwriting systems, their middle managers were not managing in traditional ways but were participating more substantively in the work of the firm.[19]

There is legitimate concern that electronic surveillance can monitor every keystroke and track every moment of a typist's life. Telephone company supervisors can measure the precise length of time an information operator spends handling each call, know precisely when the operator takes a break, and listen in on all calls.[20] Between 20 and 35 percent of all clerical workers (4 to 6 million people) may be monitored by electronic equipment.[21]

Obviously, data gathering is needed for purposes other than monitoring individuals; data collected electronically from individual work stations is apparently used to evaluate individuals in only about half the cases.[22] While electronic surveillance is chilling, it is not obvious that this represents greater intrusion than more traditional systems in which supervisors personally monitored performance. Automated surveillance monitors only the most routine activities, and many of the characteristics of "electronic sweatshops" seem applicable only to the most mechanical tasks. Most jobs requiring judgement, and most jobs "with new applications," are not susceptible to electronic supervision.[23]

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[14] C.H. Deutsch, "U.S. Industry's Unfinished Struggle," *The New York Times*, Feb. 21, 1988, p. 7.

[15] John Hoerr, "Getting Man and Machine to Live Happily Ever After," *Business Week*, No. 2995, Apr. 20, 1987, p. 61.

[16] B. Johnson and R.E. Rice, "Policy Implications in Implementing Office Systems Technology," paper presented at the 11th Annual Telecommunications Research and Policy Conference, Annapolis, MD, April 1983.

[17] H. Hartmann, R.E. Kraut, and L.A. Tilly, ed., *Computer Chips and Paper Clips: Technology and Women's Employment*, National Research Council (Washington, DC: National Academy Press, 1986).

[18] 9-to-5, "The 9-to-5 National Survey on Women and Stress," National Association of Working Women, Cleveland, OH, 1984.

[19] Peter Nulty, "How Managers Will Manage," *Fortune*, vol. 115, No. 23, Feb. 2, 1987, p. 50.

[20] See R. Howard, op. cit., footnote 11; R. Rice et al., "The Survival of the Fittest: Organizational Design and the Structuring of Word Processing," paper presented at the meeting of the Academy of Management, Dallas, TX, August 1983; and U.S. Congress, Office of Technology Assessment, *The Electronic Supervisor: New Technology, New Tensions*, OTA-CIT-333 (Washington, DC: U.S. Government Printing Office, September 1987).

[21] *The Electronic Supervisor*, op. cit., footnote 20, p. 32.

[22] See H. Hartmann et al., ed., op. cit., footnote 17; and "The 9-to-5 National Survey on Women and Stress," op. cit., footnote 18.

[23] Alan Westin et al., "Privacy and Quality of Work Life Issues in Employee Monitoring," contract report prepared for the Office of Technology Assessment, 1986, cited in *The Electronic Supervisor*, op. cit., footnote 20.

Ironically, while factory and "back office" production is moving away from hierarchical management, many occupations not traditionally tied to any formal bureaucratic management—such as physicians, teachers, residential construction managers, and farm managers—may find themselves increasingly enmeshed in bureaucracies. Physicians are often now employees of health maintenance organizations. Professionals with training in business as well as agriculture are now managing large farms. Teachers may find themselves in structures more familiar in other information industries if technology leads to greater specialization in teaching functions.[24] It may be technically possible to introduce rigid, hierarchical management into such systems by greatly reducing the autonomy of these professions. It is more likely that these systems will move toward a new form of management strategy—being neither hierarchical nor a network of independent individuals.

The collapse of traditional hierarchies in many networks has led to new roles for managers. Chapter 10 documented a rapid growth of people identified as "managers" that is not matched by growth in traditional management support personnel. These statistics alone suggest that the daily tasks of managers are more closely integrated with work done by other staff members. The integration ranges from managers who do their own typing and data analysis because word processing and data manipulation has been vastly simplified by automation, to store managers who double as sales staff because routine management has been simplified by centrally controlled software.

General v. Specific Skills.—Even if average skill levels increase, wages could go down if employers treat workers as relatively interchangeable commodities. Skills could become more homogeneous while tasks grow more specialized. This change has advantages, in that it allows people with solid basic training to help their firms adjust rapidly to new requirements. Convergence of skills can give workers greater mobility, affording them a certain degree of immunity to problems in a particular firm or industry. Generalized skills can, however, also make workers more of a mass commodity, and can greatly weaken the ability of the worker to bargain with employers.[25]

Rapid growth in temporary help businesses seems to argue that there is strong demand for skills not linked to the special interests of individual firms. This growth has been aided, of course, by an increasing tendency on the part of many U.S. firms to reduce long-term commitments, so as to adjust staffing according to short-term need; until recently, temporary workers were thought of as little more than replacements for absences, or "fill-ins" during peak workloads. Today's temporary employees are often those with skills so transferable that they need no specific training to work in an unfamiliar firm. Temporary employment agencies contributed nearly 3 percent of total job growth between 1982 and 1985—the average number of workers employed by these firms at any given time doubled during this period, reaching 735,000 at the end of 1985 and 786,000 by 1986. Nearly one-third of this total was employed by the Federal Government.[26] While many of these temporary individuals specialize in office work, a growing number are also industrial workers (typically low-paid helpers, laborers, or material movers), nurses, nursing aids and orderlies, and even people needed for defense work in engineering job shops.[27]

Income and Compensation

The changes in the mix of skills required by the U.S. economy are of more than theoretical interest. They can translate directly into changes in the distribution of wages. The value attached to different skills changes in complex ways, depending on both the supply of workers offering different training, experience, and talents and the demand for labor.

Both supplies and demands are changing. When the baby boom generation was entering the job market, entry level workers typically had more education and less experience than the ones they replaced. Accordingly, the older workers of tomorrow are likely to have increased expectations based on both education and experience. The economy will need to expand at least 2.5 percent per year for the next two decades simply to pay the baby boom work force wages equivalent to those paid today for experienced workers with equivalent educations.[28] Wages are also under pressure because Americans find themselves in direct competition with foreign producers (see ch. 7).

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[24] For a review of these studies see H. Hartmann et al., ed., op. cit., footnote 17.

[25] Harry Braverman, *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century* (New York: Monthly Review Press, 1974).

[26] Eileen Applebaum, "Alternative Work Schedules of Women," paper presented to the Economics Department of Temple University, Philadelphia, PA, July 1985.

[27] M.L. Carey and K. L. Hazelbaker, "Employment Growth in the Temporary Help Industry," *Monthly Labor Review*, vol. 109, No. 4, April 1986, pp. 37-44.

In theory, workers can increase the "quality" of the services offered by investing in education and by virtue of job experience. In fact, markets depend on a variety of factors that cannot easily be quantified.[29] Wages can depend on the relative cost of capital and workers. Real wages have fallen while real capital costs have, if anything, increased during the past few years. Compensation (wages, salaries, and benefits) has not grown as fast as labor productivity, and the fraction of national income paid as compensation has declined.

Discrimination on the basis of sex, race, and other factors still plays a role in setting wages. There are also deep cultural factors that determine how much a person should be paid to work in dangerous or unpleasant occupations or in occupations that are attractive or rewarding. The logic of these factors hinges on values that are difficult to forecast.

International competition may force managers to rethink basic strategies for rewarding pay. The ratio of pay between U.S. managers and U.S. blue-collar workers within manufacturing is at least twice the equivalent ratio in Japan.[30] Are American managers prepared to argue that the U.S. scheme is based only on a concern about maximizing the performance of their firms?

It is apparent that major changes are underway. The following discussion will trace some of the factors that connect changes in the structure of the economy with changes in links connecting skills and income. It begins by examining overall trends in compensation paid, attempting to explain how real GNP per capita could be increasing while real wages are declining. It then addresses some of the factors that lead to changes in the way the funds available for compensation are allocated on the basis of occupation, race, sex, and other factors.

Shares of National Income

Patterns of growth in income and wages appear to have changed sharply in the early 1970s. Averaging out the effects of recessions, real per capita GNP has increased steadily for a generation but real weekly earnings received by private workers in 1985 were nearly 14 percent below their 1973 peak. The real hourly wages of non-supervisory workers in private businesses declined by 10 percent during the same period.[31] Younger workers fared particularly poorly.[32] While gains in compensation roughly followed gains in productivity during the 1970s, they diverged in 1980 (see figure 1-20 of ch. 1). Productivity grew sharply between 1982 and 1986, but compensation barely recovered from the 1982 recession.

These paradoxes are explained by four factors (box 11-B provides a guide to the accounting vocabulary used in the next few paragraphs):

1. Compensation grew more rapidly than GNP between 1950 and 1970, but has grown slightly more slowly than GNP since 1970.
2. The fraction of compensation received as wages and salaries is declining, as a growing share of compensation is paid as benefits.
3. The fraction of personal income received as wages and salaries is declining, as transfer payments (particularly payments made to retirees) and unearned income capture a growing fraction of all personal income.
4. The fraction of the population working has increased.

One of the most basic changes is that that the fraction of GNP paid as depreciation increased steadily during the 1970s. This reduced the amount that could be paid to individuals in the form of compensation or investment income. An increase in depreciation would be expected from an economy going through a major transformation, since a significant amount of capital stock would become obsolete.

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[28] See W.H. Esselman and O.S. Yu, "Economic Growth to Meet Income Expectations," *Journal of Policy Analysis and Management*, vol. 2, No. 1, fall 1982, pp. 111-118.

[29] G.S. Becker, *Human Capital* (Chicago, IL: University of Chicago Press, 1975).

[30] I. Hattori, "Product Diversification," in *Effective Management: A Japanese View*, TBS-Britannica, Tokyo, 1983 (Cambridge, MA: The MIT Press, 1984).

[31] U.S. Department of Labor, Bureau of Labor Statistics, *Handbook of Labor Statistics*, 1982; and *Employment and Earnings*, vol. 33, No. 11, November 1986.

[32] The William T. Grant Foundation Commission on Work, Family, and Citizenship, "Youth and America's Future," Washington, DC, p. 21, based on analysis of March 1974 and March 1987 Current Population Survey Public Use Tapes, calculations by Center for Labor Market Studies, Northeastern University, Boston, MA.

Compensation's share of GNP has fallen slightly since the early 1970s, while the share of GNP paid as wages and salaries has dropped at a faster rate (see figure 11-4). Expanding imports, heightened domestic competition, and a variety of other factors obviously created considerable pressure for wage restraint; workers are seeing a smaller fraction of their compensation in the form of wages and salaries. Wages have come under particularly intense pressure in the heavily unionized High Wage Manufacturing industries (see ch. 10). Since 1981, each year has seen record low or near-record low wage adjustments as measured by the Bureau of Labor Statistics.[33]

The personal income (as distinct from GNP—see box 11-B) that did not go into wages, salaries, and benefits went to transfer payments and returns to capital. Private and public pensions and other benefits grew quickly during the past two decades. Aid to families with dependent children and other types of transfers grew sharply during the late 1960s, but have not since grown in percentage terms (see figure 11-5). Employer contributions for social insurance have tripled since 1950 (as a fraction of all personal income), while employer contributions for health insurance have grown eightfold. Many unions have solicited increases in benefits in lieu of taxable wage benefits; indeed, employer benefits are often greater in sectors characterized by high levels of unionization (see table 11-5).

After falling steadily for 25 years, "unearned" income (money collected from proprietary income and rent, dividends, and interest payments) has been increasing as a fraction of all personal income since the mid 1970s (its GNP share has been constant since 1970).[34] Figure 11-6 suggests that the increase is due almost entirely to interest income, which has grown far more rapidly since 1976 than during the two previous decades—possibly due to the comparatively high real interest rates of the past decade.

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[33] This BLS series dates back 18 years, and covers private industry agreements covering 1,000 workers or more. See Joan Borum and James Conley, "Wage Restraints Continue in 1985 Major Contracts," *Monthly Labor Review*, vol. 109, No. 4, April 1986, pp. 22-28.

[34] This form of income has, however, *not* captured a growing share of GNP, suggesting that the portion of "property type income" paid as personal income is shrinking while depreciation, retained earnings, and other categories are gaining share.

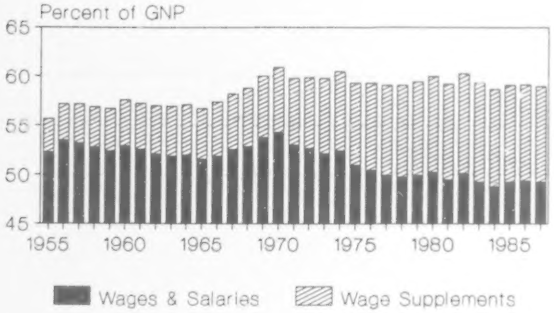
Box 11-B.—U.S. Gross National Product and Personal Income in 1986 (trillions of dollars)

Gross national product	**$4.2**	**Personal income**	**$3.5**
Compensation	2.5		
Wages and salaries	2.1	Wages and salaries	2.1
Supplements to wages and salaries	0.4	Other labor income (supplements less employer contributions to social insurance)	0.2
Proprietors' income and rental income adjusted for depreciation (a)	0.3	Proprietors' income and rental income adjusted for depreciation (a)	0.3
Net interest	0.3	Personal interest income (b)	0.5
Corporate profits adjusted for depreciation (a,c)	0.3	Personal dividend income	0.1
Depreciation(d)	0.5		
Indirect business taxes & other (e)	0.3	Transfer payments	0.5
		less personal contributions for social insurance	—0.2

(a) More precisely, these "property-type" incomes reflect inventory valuation and capital consumption adjustments.
(b) Personal interest is net interest, plus interest paid by government, plus interest paid by consumers to business, less interest received by government.
(c) Corporate profits include dividends, undistributed profits, profits tax liability, inventory valuation, and capital consumption adjustment.
(d) Capital consumption allowance with capital consumption adjustment.
(e) Business transfer payments, less subsidies, less current surplus of government enterprises (together, these are less than $0.02 trillion)

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, July 1987, Table A.

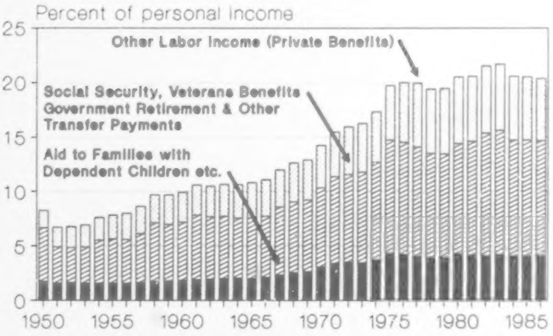
Figure 11-4.-Compensation and Wages & Salaries as a Percent of GNP (current dollars)



How To Read This Figure: Wages and salaries paid to employees were about 54% of GNP in 1970 but fell to 49% of GNP in 1986. Compensation paid to employees—defined as wages and salaries, employer contributions for social insurance, and "other labor income" (a category including employer contributions to pensions, profit sharing, group insurance, workers' compensation, supplemental unemployment, and directors' fees)—was slightly more than 60% of GNP in 1970 and is now slightly below 60%.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 2.1.

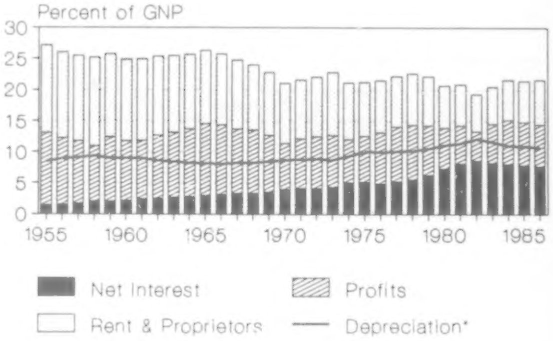
Figure 11-5.-Transfers and Benefits (as a percent of personal income in current dollars)



How To Read This Figure: Transfer payments (which include old-age, survivors, disability, and health insurance benefits; government unemplyment insurance benefits; veterans benefits; government employees retirement benefits; and aid to families with dependent children) rose from about 5% of personal income in 1950 to 15% in 1981. Transfer payments plus "other labor income" (see definition in figure 11-4) totaled 20% of personal income in 1986. In addition to these two components, personal income includes: wages and salaries, proprietors' income, rental income, personal dividend income, and personal interest income (less personal contributions for social insurance).

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 2.1.

Figure 11-6.-Property-Type Income as a Percent of GNP (current dollars)



How To Read This Figure: Property-type income (the sum of rental income, proprietors' income, corporate profits, and depreciation) was about 25% of GNP in 1960, is now about 21% of GNP. Net interest increased from 2% of GNP in 1960 to 7% in 1986. Profits (defined as corporate profits adjusted for inventory valuation and depreciation) fell from 12% of GNP in 1950 to 5.6% in 1986.

*Capital consumption allowances with capital consumption adjustment.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 1.1, 1.9, and 1.14.

Trends in the Dispersion of Compensation

As the total fraction of GNP paid as wages and salaries is declining, it is not surprising that there has been concern about how available funds are allocated. This proves to be a vexing subject because existing data makes it difficult to determine whether inequality is growing or shrinking.[35]

It is clear that inequality in the way both wages and capital earnings are allocated by family has increased (see figure 2-8 of ch. 2). Only the highest income families enjoyed real increases in labor income, with families in the the top 1 percent and top 5 percent enjoying particularly large growth. Growth in unearned income has been allocated more evenly,

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[35] In addition to the discussion in ch. 2 (see especially footnote 33 of that chapter), see Lucy Stetson Gorham, *U.S. Industry Employment Trends from 1969 to 1995 and the Implications for Economic Inequality*, Massachusetts Institute of Technology, Department of Urban Studies and Planning, Cambridge, MA, 1984; Barry Bluestone and Bennett Harrison, "The Great American Job Machine," Study Prepared for the Joint Economic Committee of the U.S. Congress, Dec. 9, 1986; Janet L. Norwood (Commissioner, U.S. Bureau of Labor Statistics), "The Job Machine Has Not Broken Down," *The New York Times*, section 3, p. 3, Feb. 22, 1987; Richard M. Cyert and David C. Mowery, eds., *Technology and Employment: Innovation and Growth in the U.S. Economy* (Washington, DC: National Academy Press, 1987).

Table 11-5.—Other Labor Income by Industry (as percent of compensation)

	1950	1960	1970	1980	1985
Agriculture, forestry, fishery	0.3	2.0	2.8	5.4	5.2
Mining	4.7	7.5	8.8	12.0	11.3
Construction	2.6	2.4	3.5	8.8	10.5
Manufacturing	3.0	6.2	7.9	12.3	12.7
Durable	2.7	6.3	8.5	12.8	13.0
Nondurable	3.4	6.1	7.1	11.6	12.3
Transportation	2.0	3.8	4.8	9.3	10.1
Communications	6.4	7.3	12.7	16.6	18.3
Electric & gas utilities	6.0	9.0	9.8	15.4	15.9
Wholesale trade	1.2	2.8	4.3	6.7	7.2
Retail trade	1.3	2.3	3.6	5.5	6.2
FIRE[a]	4.0	6.0	7.3	10.9	10.4
Other services	0.9	2.0	3.0	6.1	6.8
Government	0.1	0.2	1.1	3.2	4.5

[a] Finance, insurace, and real estate.

NOTE: For definition of "other labor income," see figure 11-4.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, Table 6.13.

with the top 40 percent of all families enjoying some growth in capital income.

Taking all sources of income together, it appears that the real income of most American families has declined in recent years and that the gap separating the wealthiest and poorest families has increased. The discussion of chapter 2 suggested, however, that many of these changes have resulted from demographic factors (e.g., smaller family sizes, growth of households headed by women) and from correlations between the earnings of husbands and wives. Adjusting for family size and numbers of earners, and using what may be a more appropriate adjustment for inflation, it appears that most family types enjoyed real growth in total income between 1970 and 1986. Families headed by eldery people did comparatively well (their incomes grew 50 percent between 1970 and 1986), while the incomes of both young families and families consisting of single mothers with children experienced no significant gains. Even making these adjustments, however, family incomes were less equally distributed in 1986 than in 1970.[36]

The changes underway in the economy are likely to affect most of the factors that determine wages. It appears, for example, that discrimination on the basis of gender is shrinking while inequality growing out of differences in educational attainment is growing. Income transfers have the effect of eliminating some of the differences between Americans who are employed and those who are retired or otherwise without income. New patterns of investment in emerging industries can alter the mix of returns paid to labor and capital. Capital investment is increasing in networks that once contributed value-added primarily through labor, such as health, education, and insurance processing.

Table 11-6 shows the compensation paid in the industries where jobs were being added most rapidly and most slowly between 1983 and 1986. On average, the jobs created paid better than the average job, but the patterns of relative change are difficult to explain. There is little correlation between wage growth by industry and productivity growth, and little correspondence between high wages and high rates of job growth.[37] Some of the industries that added the most full-time-equivalent jobs after the recession paid low wages while others paid well.

Wages and salaries paid to men have become more unequal over the last 20 years (see figure 11-7). There was a sharp rise in inequality during the recession of 1982 that was not reversed during the subsequent recovery; employers appear to have made major wage adjustments during the period. Wages paid to women, on the other hand, appear to have become more equal during the same period, although inequality has grown slightly since 1981.

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[36] U.S. Congress, Congressional Budget Office, "Trends in Family Income: 1970-1986," (Washington, DC: U.S. Government Printing Office, February, 1988).

[37] A regression examining the connection between wages and job growth shows an R^2 below 0.1.

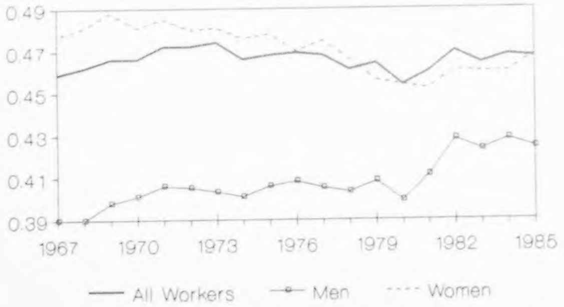
Table 11-6.—The 12 Industries with the Highest and Lowest Growth in Full-Time Equivalent Employees Between 1983 and 1986

	Compensation per full-time equivalent job ($1986)	Percent above or below 1986 compensation average	Job Growth 1983-1986 (000s)
Highest growth industries:			
Retail trade	$16,183	−38.5	2,094
Business services	$23,105	−12.2	1,180
Construction	$28,499	8.4	888
Health services	$25,271	−3.9	524
Wholesale trade	$30,129	14.6	460
Other services	$26,885	2.2	301
Education	$28,159	7.1	231
Miscellaneous professional services	$33,175	26.1	222
Social services and membership organizations	$15,679	−40.4	221
Hotels and other lodging places	$16,603	−36.9	197
Credit agencies other than banks	$26,360	0.2	187
Trucking and warehousing	$27,577	4.9	171
Lowest growth industries:			
Oil and gas extraction	$40,727	54.9	−142
Farms	$11,344	−56.9	−110
Telephone and telegraph	$43,968	67.2	−77
Primary metal industries	$38,092	44.8	−75
Leather and leather products	$17,694	−32.7	−52
Railroad transportation	$48,379	83.9	−51
Apparel and other textile products	$16,212	−38.4	−51
Textile mill products	$20,565	−21.8	−34
Chemicals and allied products	$40,074	52.4	−27
Petroleum and coal products	$56,600	115.2	−26
Coal mining	$45,029	71.2	−18
Metal mining	$41,122	56.4	−15

NOTE: Compensation includes employer contributions for social insurance, as well as "other labor income," pensions, group insurance, etc.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," *Survey of Current Business*, vol. 66, No. 7 July 1986, various tables.

Figure 11-7.-Measures of Inequality in Earnings (using the gini coefficient --see text for definition)



How To Read This Figure: The Gini coefficient measures inequality. A coefficient of 0 means complete equality (i.e., all workers would have precisely the same earnings), a coefficient of 1 means complete inequality (i.e., one worker would receive all earnings). The figure shows that for all workers, inequality in wage and salary earnings in 1970 was approximately the same as it was in 1985.

SOURCE: McKinley L. Blackburn and David E. Bloom, "The Effects of Technological Change on Earnings and Income Inequality in the United States," National Bureau of Economic Research, working paper No. 2337, Cambridge, MA, August 1987.

When both men and women are considered there appears to have been no significant change in inequality in wages.[38] This happens because the gap separating men and women is shrinking even while the distribution of wages among men is increasing.

The data used to make these statements have two major limitations. First, the data do not contain information about benefits paid by employers. The increase in part-time and temporary work has aggravated the difference between permanent full-time jobs paying benefits and temporary positions with few benefits. Benefits range from 18 percent of compensation in the highly unionized communication industries and 13 percent in durable goods manufacturing to 6 percent for service employees (again see table 11-5). Many women are not paid benefits.

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[38] McKinley L. Blackburn and David E. Bloom, "The Effects of Technological Change on Earnings and Income Inequality in the United States," Working Paper No. 2337, National Bureau of Economic Research, Cambridge, MA, August 1987.

Second, the data are unable to examine the distribution of earnings above a certain threshold (or "top-code") established by the U.S. Bureau of the Census for each year. Since much income growth has apparently occurred in the highest income groups, this can be a major limitation. Changes in the "top-code" can further confuse the results.[39]

A comparison of compensation paid to individuals working in different industries avoids both of these problems but creates another. It is unable to reflect changes in compensation occurring *within* individual business sectors. An examination of distribution indicates that there has been some increase in inequality when average compensation is ranked by industry. Figure 11-8 shows that the fraction of all compensation paid by industries with high and low rates of compensation is growing. The share of all compensation paid by industries that pay less than 75 percent of the national average doubled between 1956 and 1986. Looking at the other end of the spectrum, the figure shows that in 1956, only 1 percent of all compensation was paid by industries whose average compensation was 40 percent or more above the national average; in 1986, however, 7.5 percent of compensation was paid by such industries.

The statistics cited above apply to industries and not to occupations. Chapter 10 demonstrated that there has been a significant change in the distribution of occupations *within* individual businesses. Between 1973 and 1982, more jobs appear to have been lost in occupations from the lowest wage group than from middle income groups (constant 1982 dollars); measured in current dollars, the middle group actually increased its share of the total.[40] The dangers of assuming that new jobs added in an occupation classification are the same as the average existing job have already been discussed.

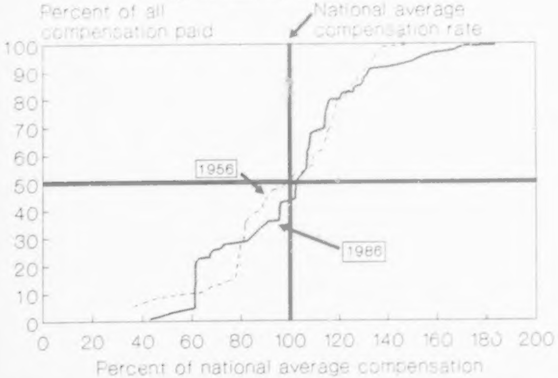
Accounting for Differences in Wages and Compensation

Some of the changing patterns of income just discussed result from changes in the education, sex, and race of the individuals entering the work force. These connections can be powerful but are difficult to trace.

The Effects of Education and Experience.—There has been considerable discussion about whether recent declines in rates of national productivity growth can be traced to changes in the quality of the U.S. work force. There are conflicting possibilities. On one hand, the entry of relatively large numbers of inexperienced workers—the baby boom generation and women without significant work experience—seems likely to have decreased overall levels of productivity. On the other hand, the new job entrants were better educated, at least as measured in terms of average numbers of years in school, than their predecessors.

The increasing levels of educational attainment shown in table 11-4 do not all result from the fact that younger workers are better educated than older ones. Figure 11-9 indicates that the major difference between young workers and older workers is a

Figure 11-8.-Distribution of Compensation, 1956 and 1986



How To Read This Figure: In 1956, 99% of all workers were paid compensation that was less than 140% of the national average compensation paid, while 10% were paid less than 60% of average compensation. In 1986, 92% of all workers were paid compensation less than 140% of the national average, while 5% were paid less than 60% of the national average.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 6.4 and 6-7.

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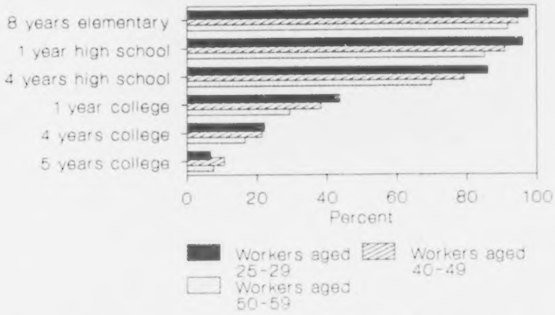
[39] See U.S. Congressional Budget Office, "The Changing Distribution of Federal Taxes: 1975-1990," (Washington, DC: U.S. Government Printing Office, November 1987); and the discussion of this subject in ch. 2.

[40] Neal Rosenthal, "The Shrinking Middle Class: Myth or Reality?" *Monthly Labor Review*, vol. 108, No. 3, March 1985, p. 4. Later work by the Bureau of Labor Statistics shows that within each occupation, there was a downward shift in average earnings between 1973 and 1982; see Patrick J. McMahon and John H. Tschetter, "The Declining Middle Class: A Further Analysis," *Monthly Labor Review*, vol. 109, No. 9, September 1986, pp. 22-27.

Figure 11-9.-Education Levels of Workers in 1985 (percent of workers with education above indicated levels)



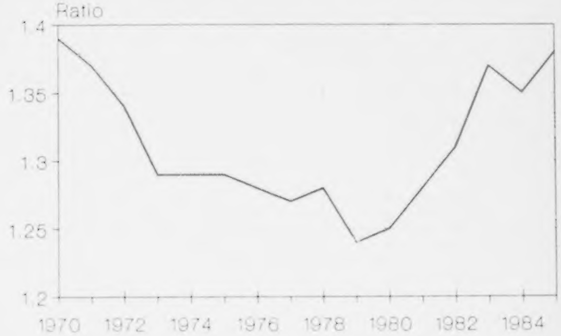
How To Read This Figure: In 1985, 97.8% of workers aged 25-29 had at least eight years of education while 91.8% of workers aged 50-59 had at least eight years of education.

SOURCE: U.S. Department of Education, Center for Education Statistics, *Digest of Education Statistics 1987* (Washington, DC: U.S. Government Printing Office, May 1987), table 9.

higher rate of completion of high school. Workers aged 40-49 are actually more likely to have advanced degrees than their younger colleagues, presumably because many returned to get degrees. Unfortunately, these statistics say nothing about the *quality* of the education produced; chapter 3 provided some evidence suggesting a decline in educational quality.

Returns to investments in education appeared to be falling during the early 1970s, in part because of the large number of baby boomers entering the work force. Many were better educated than the people they were replacing. The declining wages paid for education led in part to speculation that Americans were "over educated."[41] Figure 11-10 makes it clear, however, that education has been paying increasing returns in the 1980s. An analysis of 1980 census data for white male workers seems to reveal a much stronger return to investments in education than to work experience after age 30.[42]

Figure 11-10.-Does It Pay To Graduate From College? (ratio of income of college graduates to income of high school graduates)



How To Read This Figure: In 1979, the average worker with 4 years of college had earned income 24% higher than the average worker with only 4 years of high school (an income ratio of 1.24). By 1985, college graduates earned an average of 38% more than high school graduates (a ratio of 1.38).

SOURCE: U.S. Department of Education, Center for Education Statistics, *The Condition of Education* (Washington, DC: U.S. Government Printing Office, 1986), table 2:3.

The value of education was particularly pronounced for younger workers entering an increasingly competitive labor market. The real mean hourly earnings (1985 dollars) for civilian males aged 20-24 fell 26 percent between 1973 and 1986, but the earnings of high school drop-outs fell 42 percent while earnings for college graduates fell only 6 percent.[43]

Without attempting to adjust for the quality of education, which standardized test score trends indicate may be declining, some estimates indicate that the increased overall level of education in the work force added 0.47 percentage points to GNP growth rates between 1973 and 1982.[44]

Retraining can, however, reinforce rather than lessen inequality. The Education section of chapter 6 suggested that an important function of modern education was to prepare people to continue to learn throughout their career. This seems to be the case. People with good educations and high incomes represent the majority of all those engaged in adult education and training.[45] One-third of all people with more than 5 years of college participated in adult education in 1984, as opposed to only 2 percent of people with less than nine years of schooling. And while only 28 percent of all families in the United States had incomes over $35,000 in 1984, over 37 percent of people enrolled in adult education came from these families.[46]

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[41] R.B. Freeman, *The Over-Educated American* (New York, NY: Academic Press, 1976).

[42] A regression on the wages of white men, using the following variables [statistically significant coefficients in brackets]: average years of education [0.63], percent not in labor force in 1975, average hours [0.008], percent under 20 [-2.38], percent aged 20-29 [-1.43], percent aged 30-39, percent aged 40-49, percent aged 50-64, percent over 65 [-4.96], percent in south [0.227]; R^2 0.851. See B.T. Thornton Dill, L.W. Cannon, and R. Vanneman, "Race and Gender in Occupational Segregation," in *Pay Equity: An Issue of Race, Ethnicity and Sex* (Washington, DC: National Committee on Pay Equity, February 1987).

[43] The William T. Grant Foundation, op. cit., footnote 32.

[44] Martin Neil Baily, "What Has Happened to Productivity Growth?" *Science*, vol. 234, No. 4774, Oct. 24, 1986, p. 445.

The Effects of Race and Sex.—The rapid increase of women in the work force, and the continued, though diminishing, disparity between male and female wages, has contributed to the growing inequality in wages, as more women have entered the labor force during this period. Table 11-7, for example, indicates that while male and female wages have become somewhat more equal since 1973—the worst year for women—the ratio between female and male earnings is still far from even.[47]

Salaries of younger women more closely approach those of men (again see table 11-7). In 1979, women 20 to 24 years old earned 77 percent of the weekly earnings of their male counterparts—a fraction that grew to nearly 86 percent by 1985. The ratio for women 25 to 34 years of age increased from 0.68 to 0.75 during the same period. However, women between 45 and 54 years of age earned less than 60 percent as much as males in 1985—a fraction that did not change significantly after 1979.[48]

Between 35 and 40 percent of the pay gap separating men and women results from the occupations women choose or have forced upon them.[49] Some of the remaining gap in pay results from the fact that women have not invested as heavily in their own education as men, or have elected to choose college majors that lead to low paying occupations. Half of the earnings difference separating male and female college graduates may be explained by choice of major.[50] This, of course, leads to a question of causality. Are women underinvesting in themselves or choosing low paying majors because they do not feel that they can obtain well paying jobs, or are their choices based on other factors (interests in nursing rather than engineering) that lead to lower wages?[51]

Most professional women are teachers, but there are growing numbers in other fields (see table 11-8). Occupational segregation has declined primarily because women have entered male professions, and not the reverse. Women have done most poorly in business management; only 36 percent of administrators are women, and only 5 to 10 percent of top executives. Only one Fortune 500 company is headed by a woman—Katharine Graham of *The Washington Post*.

Table 11-9 indicates the extent to which women and minority wages are lower than white male wages because of differences in education and work experience. Much of the disparity between male and female wages, and between the wages of whites and blacks, results from segregation by occupation, rather than inequality in pay for identical work.[52] Half of all women, for example, work in occupations where two-thirds of all workers are female.[53]

Table 11-7.—Changes in Ratio of Female to Male Wages

Female/male wage ratio:*					
1960	1970	1973	1980	1985	1986
0.61	0.59	0.57	0.60	0.64	0.70

	Recent years, by age cohort:**			
	20-24	25-34	35-44	45-54
1979	76.7	67.5	58.2	57.0
1985	85.7	75.1	63.2	59.6

SOURCES: *David E. Bloom, "Women and Work," *American Demographics*, September 1986, p. 25. 1986 data provided by the Bureau of the Census, U.S. Department of Commerce, September 1987.
**Council of Economic Advisors, *Economic Report of the President*, 1987, p. 221.

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[45] See U.S. Congress, Office of Technology Assessment, *Technology and Structural Unemployment: Reemploying Displaced Adults*, OTA-ITE-250 (Washington, DC: U.S. Government Printing Office, February 1986), p. 275.

[46] U.S. Department of Education, Center for Education Statistics, *The Condition of Education* (Washington, DC: U.S. Government Printing Office, 1986), based on "Current Population Survey," Washington DC, May 1984.

[47] The ratio between male and female wages seems to have considerable durability, as evidenced by this passage from Leviticus 27.1-4:

> The Lord spoke to Moses and said, "When a man makes a special vow to the Lord which requires your valuation of living persons, a male between twenty and sixty years old shall be valued at fifty silver shekels. If it is a female, she shall be valued at thirty shekels."

[48] Council of Economic Advisors, *Economic Report of the President*, January 1987, Washington, DC, p. 221.

[49] D.J. Treiman and H.I Hartmann, ed., *Women, Work, and Wages: Equal Pay for Jobs of Equal Value* (Washington, DC: National Academy Press, 1981).

[50] Ibid.

[51] Kenneth Arrow, "Economic Dimensions of Occupational Segregation: Comment I," in *Signs: Journal of Women in Culture and Society 1, pt. 2* (Sprint, 1976), pp. 233-237.

[52] W.T. Bielby and J.N. Baron, "Men and Women at Work: Sex, Segregation and Statistical Discrimination," *American Journal of Sociology*, vol. 91, pp. 759-799.

[53] B.T. Thornton Dill et al., op. cit., footnote 42.

Table 11-8.—Percent Female in Selected Occupations

	1970	1986
Architects	4	8
Bus drivers	28	50
College & university teachers	29	37
Computer scientists	14	28
Doctors	10	18
Lawyers	5	20
Technicians	34	47
1st year medical students	9[a]	34

[a] Represents 1969 ratio.

SOURCES: David E. Bloom, "Women and Work," *American Demographics*, vol. 8, No. 9, September 1986, p. 25. Council of Economic Advisors, *Economic Report of the President*, 1987, p. 219.

The disadvantages faced by blacks in the American workplace have been painfully difficult to change. Black unemployment is at least twice that of whites in all age groups except women over 55, while black male teenagers with work experience dropped from 67 to 47 percent between the mid-1960s and the mid-1970s; current unemployment among black teenagers is close to 50 percent. Differences in levels of educational attainment are creating growing inequality among blacks. The earnings of young black male high school drop-outs *fell* 61 percent between 1973 and 1986 while the earnings of black college graduates *increased* 6.5 percent.[54]

The heavy hand of history continues to limit black mobility. Blacks are comparatively immobile because of their concentration in inner cities, while many attractive jobs are opening in suburban and exurban areas poorly served by public transportation (see the last section of ch. 5). Poor neighborhoods and other factors contribute to comparatively weak educational experiences. A history of unemployment and underemployment further limits opportunity; a large fraction of young blacks has already been scarred by chronic unemployment. Many reach their prime working age without any successful work experience.[55]

One of the greatest barriers facing minorities is the way they have been served by the educational system. While there are not major racial differences in "median years of school completed," there appears to be a significant disparity in the quality of the education obtained (see figure 11-11).

Flexibility and Job Security

Americans have always been willing to tolerate frequent job changes. Unlike workers in most other developed countries, Americans frequently change jobs and even move to different parts of the country to find them. This mobility has been a source of strength for the U.S. economy, allowing it to shift with comparative ease into new production systems.[56]

But an economy that achieves flexibility largely through the use of "disposable" workers, who accumulate little experience and have little loyalty to

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[54] The William T. Grant Foundation, op. cit., footnote 32.

[55] J. Norwood, "The Future of Employment," op. cit., footnote 2.

[56] *Technology and Structural Unemployment*, op. cit., footnote 45, p. 144.

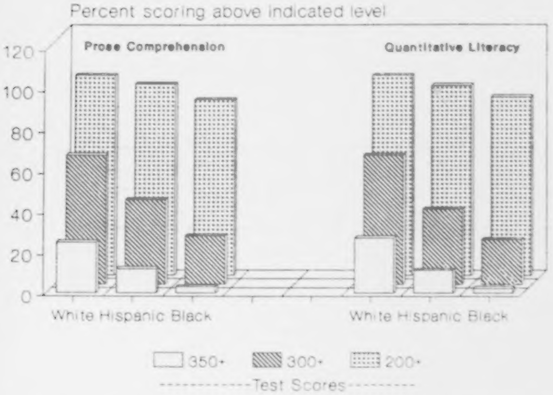
Table 11-9.—The Effects of Education, Experience, Sex, and Age on Income

	Male occupations (<34.1% F)	Female occupations (>34.1% F)	Effect on expected female earnings
Average education	13.2	13.5	+1.9 percent
Average hours	44.2	43.0	−1.0 percent
Percent under 30	27.5	30.8	−5.3 percent
Percent new workers	10.0	12.7	−1.1 percent
	White occupations (<34.1% Min.)	**Minority occupations (>34.1% Min.)**	**Effect on expected minority earnings**
Average education	14.2	12.1	−11.7 percent
Average hours	44.4	42.9	−1.3 percent
Percent under 30	24.4	34.5	−15.0 percent
Percent new workers	9.2	13.3	−1.6 percent

How To Read This Table: Individuals in occupations that were predominently male had an average education of 13.2 years, while individuals in predominently female occupations had an average of 13.5 years of education. This factor would cause the female occupations to pay 1.9 percent more than the male occupations.

SOURCE: B.T. Thronton Dill, L.W. Cannon, and R. Vanneman, "Race and Gender in Occupational Segregation," *Pay Equity: An Issue of Race, Ethnicity Sex*, National Committee on Pay Equity, February 1987. Work based on 5 percent sample of 1980 census data from U.S. Department of Commerce, Bureau of the Census.

Figure 11-11.-Literacy Skills by Race



How To Read This Figure: Americans aged 21 to 25 were given a series of tests in 1985 to determine literacy levels (some of the results of this test are also reported in table 3-27 of ch. 3). In the prose comprehension portion of the test, 25% of the whites but only 3.1% of the blacks who took the text received scores of 350 or more; 98% of whites and 86% of blacks recieved a score higher than 200.

SOURCE: U.S. Department of Education, Center for Education Statistics, *Digest of Education Statistics 1987* (Washington, DC: U.S. Government Printing Office, May 1987), table 11.

an individual employer, pays a considerable price. Some of the cost appears in productivity lost because of continual personnel changes. There are high social costs as well. Often the people most heavily affected are those with the fewest resources.

While employers are demanding and receiving greater flexibility from their workers, there has also been increased demand in the work force for nonstandard work hours. Mothers of small children, students, the elderly, and others wanting to combine paid jobs with outside activities seek options other than full-time employment from 9:00 AM to 5:00 PM. Many would prefer to adjust their working hours as needs change from week to week.

It appears that the new production and service networks being built around many different markets can provide greater options for both employees and employers. Technology can help by lowering the transaction costs associated with monitoring uneven work schedules, by improving the tools used to train and retrain people needing to move to new jobs, and even by creating options to work at home.

In the past, it was common to attribute a lack of flexibility to union work rules or other contractual rigidities. While these complaints are still heard, they have greatly diminished. Many contracts now contain provisions to help employees adjust to new technologies, and unions have generally recognized the need for productivity growth and technical change in an increasingly competitive world.[57]

The Employer's Perspective

Firms have reacted to demands for greater flexibility and adaptability in a variety of ways. Flexibility is inherent in sectors where small businesses are continually formed and disbanded. Small businesses are often bound by few inhibitions in hiring and firing. Many larger firms have tried to achieve flexibility by minimizing commitments to employees and by hiring large numbers of "contingent" workers (see below).

There are also many cases where firms have made a conscious effort to gain flexibility by investing in their employees. Chapter 3 documented the enormous investment being made in education and training at the corporate level. Other firms have found ways to use profit sharing to spread the pain of economic hard times among many workers, rather than letting a few bear the burden when they are laid off. Some have allowed greater choice in work schedules—permitting employees to adjust their work to home needs.

There is no clear indication of which strategy is prevailing, or which is most likely to succeed under the rules now governing the U.S. economy.

Traditional Strategies for Flexibility.—U.S. businesses have always achieved flexibility through plant closings and layoffs, coupled with new hiring in areas where growth is occurring. There is no sign that this strategy is changing. Between January 1981 and January 1986, 10.8 million jobs were lost due to plant closings, abolition of positions, or slack work.[58]

New techniques for achieving flexibility are now coming into wider use. Businesses unwilling to undertake the cost of hiring permanent workers during periods of long-range uncertainty have turned increasingly to part-time and temporary workers.

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[57] See Cyert and Mowery, op. cit., footnote 35, for a review of this subject.

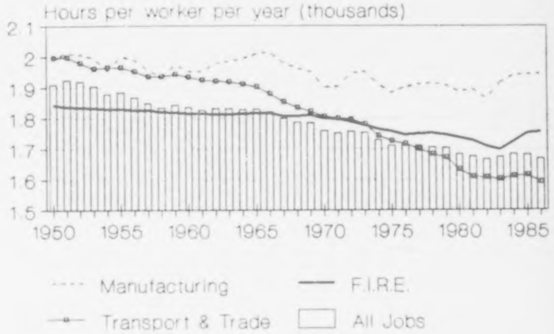
[58] Francis W. Horvath, "The Pulse of Economic Change: Displaced Workers of 1981-1985," *Monthly Labor Review*, vol. 110, No. 6, June 1987, pp. 3-12.

Over the past decade, there has been significant growth in the number of contingent workers—individuals employed temporarily, subcontracted from an intermediary firm, part-time workers, and self-employed individuals. Taken as a whole, this group increased 25 percent between 1975 and 1985 (compared to total employment growth of 22 percent). There are now 30 million employees in these categories—27 percent of the labor force.[59] The growth of a contingent work force may also mean that a significant number of people will find themselves without work during recessionary periods, as firms seek to streamline costs by cutting back on employment of subcontractors or temporaries. This could be particularly true among service sector businesses, many of which are now considered to be relatively insulated from the impact of recessions.

The comparative decline of employment in manufacturing has also reduced the proportion of traditional, 40-hour per week "full time" jobs. Not only do most service businesses have lower average numbers of working hours, the hours per job in these businesses have been declining (see figure 11-12). Hours fell sharply in the fast-growing retail businesses. Time devoted to finance, insurance, and real estate activities declined until the early 1980s, but the trend was reversed when this sector rebounded from the 1982 recession.

It is obvious that a lack of commitment to employees can carry a high price. Constant turnover can prevent the development of effective working teams that seem critical to productivity.[60] Most new production systems and delivery networks involve a considerable amount of informal, on-the-job learning. The costs of this learning are high, but are seldom recorded (see notes to table 3-26 of ch. 3). Attempts to avoid training can prove costly. A survey of firms attempting to introduce new automation during the past few years found that the training needs associated with new equipment were "vastly underestimated" in most of the cases examined.[61]

Figure 11-12.-The Decline in Hours per Job in Different Businesses



How To Read This Figure: In 1950, the average worker in finance, insurance and real estate (F.I.R.E.) businesses worked approximately 1,840 hours per year. By 1986, employees in F.I.R.E. averaged 1,755 hours per year.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, tables 6.6 and 6.11.

Firms unable to command loyalty are vulnerable to raids on valuable workers. The problem is particularly acute in the rapidly growing "high technology" sectors of the U.S. economy, where many firms make a business of luring crucial employees from each other. Intel was co-founded by Robert Noyce, Andrew Grove, and Gordon Moore, who helped invent the integrated circuit before leaving Fairchild. Zilog was founded by seven Intel executives; LSI Logic was founded by former Fairchild executives; and MOS is the brainchild of ex-Motorola Employees. Lester Hogan abandoned General Electric with 18 engineers to work at Motorola, and then left Motorola for Fairchild. It is not uncommon for semiconductor executives, engineers, and programmers to have worked for half a dozen firms;[62] similarly, turnover rates in the U.S. electronics industry are 20 to 30 percent per year.[63] Of course, these moves may be as much the result of opportunities in the recipient enterprises as of some sub-standard commitment to employees among firms losing key workers.

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[59] S. Christopherson, "Peak Time, Slack Time: The Origins of Contingent Labor Demand," Working Paper Series 117, Institute of Industrial Relations, University of California at Los Angeles, October 1986.

[60] See John E. Ettlie, "Facing the Factory of the Future," paper prepared for the National Science Foundation by the Center for Social and Economic Issues, Industrial Technology Institute, Ann Arbor, MI, August 1984.

[61] B. Johnson and R.E. Rice, op. cit., footnote 16.

[62] Charles H. Ferguson, "U.S. Microelectronics in Decline: Evidence, Analysis, and Alternatives," Massachusetts Institute of Technology, VLSI Memo No. 85-284, Cambridge, MA, December 1985.

[63] U.S. Electronics Association, 1980, cited in Ibid.

Alternative Strategies for Flexibility.—

Profit Sharing.—There is compelling theoretical evidence to suggest that firms may be collectively better off if they find a way to share the risks more equitably among their employees by adjusting compensation for all workers instead of placing most of the cost on the few who must be let go.[64]

A variety of mechanisms are possible, but all involve making some portion of employee compensation vary with a firm's profitability. In addition to being a mechanism for keeping employment comparatively steady, profit sharing can be used as a management tool to provide employee incentives. A number of firms have reported successful experiments in profit sharing as a tool in motivating employees. An observer looking at a program in the Philips Company, where bonuses average 40 percent of an employee's pay, reports that motivation is so strong that "if a husband dies, the wake is at night so that no one misses work."[65] Firms that elect to manage their operations by giving individual managers considerable independence, such as managers of most franchised service stations, expect the managers to bear the risks and rewards of fluctuating profits.

Perhaps the Nation's premier example of profit sharing is Lincoln Electric, the world's largest manufacturer of arc-welding products. The company pays 6 percent of net income in common stock dividends. Of the rest, bonuses range from 20 to 120 percent on top of base salaries that are already competitive. Although national statistics are difficult to read, it appears that while few firms have gone as far as Lincoln, there has been significant growth in schemes to share profits and risks. A recent survey of a variety of data sources revealed the following:[66]

- half a million companies have some form of profit sharing;
- at least 6 major airlines and 15 companies have employee ownership plans taken in response to deregulation and cost pressures that followed;
- overall, 11 million employees in 8,000 businesses now own at least 15 percent of the companies employing them;
- in 1983, 19 percent of all production employees, 27 percent of all technical and clerical employees, and 23 percent of all professional and administrative employees were covered by profit sharing agreements;
- the National Bureau of Economic Research found that "one-shot" bonus payments, replacing general pay increases, were called for in almost 20 percent of all 1985 union contracts, up from 6 percent in 1984;
- 20 percent of 564 companies surveyed by Hewitt Associates in 1986 gave one-time bonuses to white collar workers, up from 7 percent in 1985; and
- it is estimated that Ford will pay an average of $3,000 per worker in profit sharing bonuses because of the company's strong 1987 performance.[67]

In spite of the fact that the classic "Scanlon Plan" calls for 75 percent of profit sharing to go to employees, most profit-sharing schemes actually in place appear to apply primarily to professionals and managers. Top executives get most of the benefit. A study of 491 companies conducted by the Conference Board, a business research organization, showed that while 58 percent had top executive bonus plans, only 11 percent had profit sharing plans, 8 percent had all-employee bonuses, and 3 percent had group cost-control incentives. One leading bank pays bonuses of 30 percent for excellent branch managers but only 6 to 8 percent in bonuses to employees.[68]

Training and Retraining.[69]—Another way to ensure that flexibility can be achieved without layoffs is to develop planning strategies that encourage workers to adapt themselves to new jobs created as production systems change.[70] Since firms have difficulty guaranteeing that investments in worker training will rebound to their advantage, rather than to that of an employee who can take his or her knowledge elsewhere, there is an understandable reluctance for firms to invest heavily in training.

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[64] M.L. Weitzman, *The Share Economy* (Cambridge, MA: Harvard University Press, 1984).

[65] Theodore Cohn, reported in R.M. Kanter, "The Attack on Pay," *Harvard Business Review*, vol. 64, No. 2, March-April 1987.

[66] R.W. Kanter, op. cit., footnote 65.

[67] John Holusha, "Ford Had Record Net of $4.6 Billion for 1987," *The New York Times*, Jan. 28, 1988, pp. D1, D4.

[68] R.W. Kanter, op. cit., footnote 65.

[69] For a comprehensive examination of this subject, see *Technology and Structural Unemployment*, op. cit., footnote 45.

[70] R.W. Cyert and D.C. Mowery, ed., op. cit., footnote 35.

Private corporations are often forced to remedy defects in training provided by the elementary and secondary school system. For example, 18 percent of firms responding to a 1985 *Training Magazine* survey of firms with 50 or more employees said that they offered a remedial education program of some sort.[71] Nearly one-quarter of the firms surveyed in 1977 by the Conference Board reported that "some or much" of what they taught their employees in corporate training programs was "really the responsibility of the schools."[72] Similarly, 11 percent of firms surveyed in 1975 provided remedial education,[73] either in-house or in the form of tuition reimbursement, for basic education after hours. The Department of Defense is also forced to make heavy investments in remedial training.[74] In the view of one expert:

> It appears that one could cynically describe the U.S. educational philosophy as one of indifference for 18 years followed by insistence on intensive, enormously expensive retraining efforts. There seems to be insufficient time and money to do it right, but plenty of time and money to do it over again.[75]

As the previous discussion suggests, it appears that most training serves to help people with good educations stay ahead. The opportunities and problems involved are discussed in greater length in the Education section of chapter 6.

Industry pays for most retraining in the United States. The social gains from investments in training, however, can exceed the private returns realized by individual firms, and private sector retraining programs are often beyond the means of the individuals most in need of such assistance—suggesting the need for public policy that can encourage greater investment in training.[76]

Flexibility and Business Size.—There is no clear relationship between the structure of a business sector, measured in terms of the size and scope of firms, and the strategies adopted for flexibility in that sector. Analysis is restricted to anecdotes, which demonstrate that both small and large firms can provide flexibility at a comparatively low human cost.

A business network can achieve flexibility by letting small businesses and self-employed individuals absorb most of the pain of adjustment. This is the primary source of flexibility for sectors dominated by small businesses, such as construction. During economic downturns, many small construction firms either go bankrupt or are effectively closed while their owners undertake maintenance or renovation jobs.[77]

There are examples of areas where networks of small enterprises have been able to operate effectively in highly volatile situations while providing attractive work environments.[78] Small firms, however, are typically much more willing to achieve flexibility through rapid layoffs and new hires. They are far less likely to be covered by union contracts. In 1983, 18.8 percent of all U.S. employees worked under union contracts. Of this total, 4.7 percent of firms with fewer than 25 employees had such contracts, as opposed to 30 percent of all firms with more than 500 employees.[79]

Smaller firms are also less likely to help their workers adjust to new job demands, or to find new work when they are laid off. One survey found that firms with 10,000 or more employees spend on average $86 per worker for training, while firms with 500 to 1,000 employees spend $27 per worker.[80]

There is no ambiguity about the relative poverty of benefit packages offered to small business. While 67 percent of all U.S. employees are covered by an employer's health plan, for example, 85 percent of the workers in firms with more than 500 employees are covered, as compared to only 39 percent of workers in firms with fewer than 25 employees. Similarly, 56.4 percent of all workers are covered by an employer or union pension fund. Only 18.7 percent of employees in small firms are covered in such a manner, while 86 percent of employees in firms with more than 500 workers are covered.[81]

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[71] Dale Feuer, "Where the Dollars Go?" *Training: The Magazine of Human Resources Development*, October 1985, p. 48.

[72] Seymour Lusterman, *Education in Industry* (New York: The Conference Board, 1977).

[73] Ibid.

[74] See U.S. General Accounting Office, Report to the Secretary of the Army, "Poor Design and Management Hamper Army's Basic Skills Education Program," GAO/FPCD-83-19, Washington, DC, June 20, 1983; and Thomas G. Sticht, *Basic Skills in Defense*, Office of the Assistant Secretary of Defense, Manpower, Reserve Affairs and Logistics, March 1982.

[75] See U.S. Congress, Office of Technology Assessment, "Education," sector study, Washington, DC, 1987.

[76] For a recent review, R.M. Cyert and D.C. Mowery, ed., op. cit., footnote 35.

[77] See U.S. Congress, Office of Technology Assessment, *Technology and the Future of the U.S. Construction Industry* (Washington, DC: The AIA Press, 1986).

[78] This is a strategy that Charles Sable argues has worked effectively in Northern Italy and in parts of Western Europe. See Michael Piore and Charles Sable, *The Second Industrial Divide* (New York: Basic Books, 1984).

[79] U.S. Small Business Administration, *The State of Small Business* (Washington, DC: U.S. Government Printing Office, 1985), p. 253.

[80] Seymour Lusterman, op. cit., footnote 72; see also S. Lusterman, *Trends in Corporate Education and Training* (New York, NY: The Conference Board, 1985).

Small firms may also be more flexible in hiring scarce talent when a new business opportunity emerges. They have often been able to raid skilled employees from other businesses.[82] Entrepreneurs have also been able to take advantage of the training employees have received in larger firms, though small, entrepreneurial firms are often bought by larger ones.

Willingness to hire and fire workers on short notice, and to pay high premiums for crucial tasks, can combine to create a large gap between the wages of skilled and unskilled workers in small firms. The gap separating the wages of a physician and a nurse in a private practice is typically far larger than in a corporate health maintence organization.[83]

Sectors operating with a few large and dominant firms can achieve flexibility if the larger firms successfully pass the burden of adjustment to smaller "satellite" suppliers. This strategy is widely practiced in Japan, and applies to some satellite systems operating in the United States—firms such as Eli Lilly, Hewlett-Packard, and Digital have no layoff policies similar to those offered in Japan. IBM faces business downturns by curtailing contracts with supplier firms, performing this work within IBM itself.

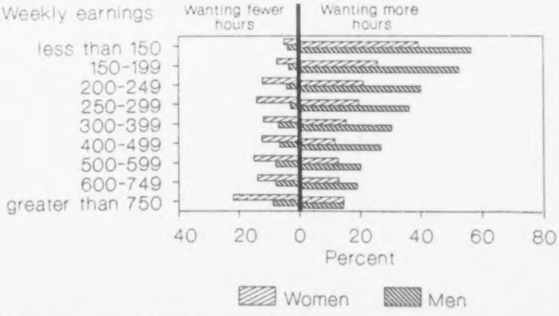
The Employee's Perspective

Employees as well as employers can desire flexibility. The key question is whether variations in work schedules are under the control of the worker or the employer. There should be reasonable ways to search for compromise.

It is difficult to estimate the underlying demand for flexibility in work schedules, if only because relatively few people have the luxury of considering such choices. There is reason to believe that a real unmet need exists among employees for greater flexibility. Parents with young children, for example, would clearly benefit from adjustable work schedules, particularly given the shortage of adequate child care facilities; a survey of women with children under five found that one-quarter were forced to curtail their working hours due to the unavailability of day care.[84] Inability to change schedules among parents has also led to such social developments as "latch key children." Many elderly people, forced to choose between the shock of complete retirement and continued full-time employment, would opt for greater flexibility if it were available. The extent to which a person is interested in more or less work is heavily dependent on income (see figure 11-13). As income rises, people are more likely to choose unpaid time than pay. Women appear to trade free time and income in a different way, but both sexes follow a roughly similar pattern.[85]

Figure 1-21 of chapter 1 makes it plain that the burden of adjustment to the emerging economy has been most painful for those with poor educations.

Figure 11-13.-Desire for More or Fewer Hours of Work (percent of workers aged 25-54)



How To Read This Figure: In 1985, about 21% of all women earning $200-250 a week wanted to work more hours, while slightly more than 12% wanted fewer hours of work.

SOURCE: Susan E. Shank, "Preferred Hours of Work and Corresponding Earnings," *Monthly Labor Review*, November 1986, p. 43.

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[81] U.S. Small Business Administration, op. cit., footnote 79, pp. 259 and 274.

[82] Presentation of Gordon Moore, Chairman & CEO of the Intel Corp., Symposium on Economics and Technology, National Academy of Engineering, Palo Alto, CA, Mar. 17-19, 1985.

[83] U.S. Congress, Office of Technology Assessment, "Health," sector study, Washington, DC, 1987.

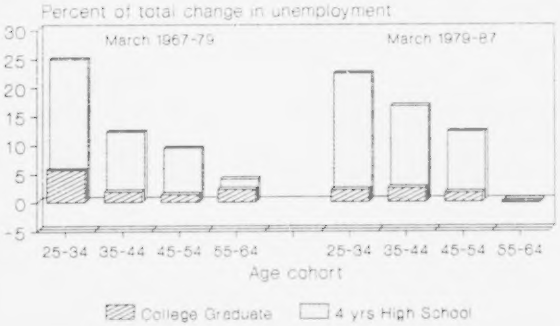
[84] E. Applebaum, op. cit., footnote 26.

[85] Susan E. Shank, "Preferred Hours of Work and Corresponding Earnings," *Monthly Labor Review*, vol. 109, No. 11, November 1986, p. 43.

People with post-graduate degrees were scarcely affected by the recessions of the early 1980s, while one high school drop-out in four was unemployed at the peak of the downturn. The figure presented in chapter 1 also forces some reflection about "natural" or "frictional" unemployment; post-graduates seem perfectly capable of keeping "frictional" unemployment below 3 percent.

Figure 11-14 shows that overall growth in unemployment can be traced largely to growing umemployment of young, poorly educated workers. Unemployment grew even for young college graduates between 1967 and 1979 as the baby boom entered the job market. Older workers also suffered growing unemployment during this period. During the 1979-87 period, however, growth in unemployment among college graduates was not responsible for any significant part of overall growth the national unemployment rate. But much of the overall increase could still be traced to rising unemployment among high school graduates—particularly younger ones.

Figure 11-14.-Contribution of Growth in Unemployment Rates by Age and Education to Increase in Total U.S. Unemployment



How To Read This Figure: Unemployment was 3.0% in March 1967, 4.2% in March 1979, and 5.7% in March 1987. This figure shows the extent to which this increase can be explained by growth in the unemployment rates of workers with different levels of education (removing the growth in unemployment due to demographic effects—e.g., the entry of large numbers of young workers who tend to have higher rates of unemployment than middle aged workers).

The figure shows that nearly 25% of the growth in the U.S. unemployment rate between March 1967 and March 1979 resulted from an increase in the unemployment rate of workers aged 25-34 who had only four years of high school; 5% of the increase could be explained by growth in the unemployment rates of college graduates aged 25-34. Similarly, 22% of the growth in the U.S. unemployment rate between March 1979 and March 1987 was attributable to a further increase in the unemployment rates of workers with high school educations aged 25-34.

SOURCE: Wayne J. Howe, "Education and Demographcis: How Do They Affect Unemployment Rates?" *Monthly Labor Review*, vol. 111, No. 1, January 1988, pp. 3-9.

While the average number of hours worked per week has not declined significantly for two generations, there has been an extraordinary amount of movement in work schedules. Figure 11-15 summarizes changes in working hours that occurred between 1979 and 1985. The 40-hour week is becoming less common, while there is considerable growth in both shorter and longer work weeks.[86]

Surprisingly few adults hold stable, full-time jobs and receive pay for 40 hours a week, 50 weeks a year. This translates into significant variation in yearly incomes. The average year-to-year change in work hours during the 1970s was nearly 320 hours (see table 11-10); while change among white men matched this average, change ranged from 280 hours for white women to 350 hours for blacks. More than 20 percent of white men reported average changes of more than 500 hours per year over the 10 year period, and nearly 75 percent experienced at least 1 year of change of at least that magnitude.[87]

With the exception of the 17 percent of the U.S. labor force working under union contracts, those working in firms having a long tradition of no layoffs, and those working for the Federal government, which until recent budget cutbacks has tended to discourage firing except in rare circumstances, few Americans have much control over their job tenure. Nearly two-thirds of all U.S. workers aged 25 and older have worked for their current employers less than 9 years, while less than 1 of every 8 people (and only 1 in 15 women) have been with the same firm for 20 or more years (see table 11-11).[88]

While strong circumstantial evidence suggests that these variations are involuntary, some variation in working hours is voluntary. Parents may elect to

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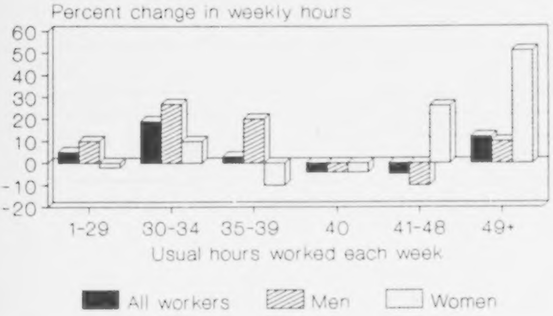
[86] Shirley J. Smith, "Growing Diversity of Work Schedules," *Monthly Labor Review*, vol. 109, No. 11, November 1986, p. 8.

[87] Greg J. Duncan, *Years of Poverty, Years of Plenty*, Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI, 1984, p. 10.

[88] Paul O. Flaim, "Work Schedules of Americans, An Overview of New Findings," *Monthly Labor Review*, vol. 109, No. 11, November 1986, p. 5.

Figure 11-15.-Change in Average Weekly Hours Worked (May 1979-May 1985)



How To Read This Figure: The number of men and women working 40 hours per week declined about 4% between May 1979 and May 1985. The number of women working more than 49 hours per week increased nearly 50% during this period.

SOURCE: Shirley J. Smith, "Growing Diversity of Work Schedules," *Monthly Labor Review*, vol. 110, No. 11, November 1986, p. 10.

work fewer hours when their children are young. University professors take sabbatical leave once every 7 years.

Table 11-10.—Year-to-Year Changes in Annual Work Hours (1969-1978)

Average yearly change in work hours	319 hours
Percent of sample with average yearly change in annual work hours	
Less than 100 hours	19 percent
100 to 250 hours	27 percent
250 to 500 hours	34 percent
More than 500 hours	20 percent
Percentage for whom work hours changed by 500 hours or more	
In at least one year	68 percent
More than half the time	11 percent

NOTE: Data applies to "household heads and wives," and includes unmarried men and women who headed households and wives of men who headed households.

SOURCE: Greg J. Duncan, *Years of Poverty, Years of Plenty*, Survey Research Center, Institute for Social Research, University of Michigan, Ann Arbor, MI, 1984.

Table 11-11.—Continuous Employment with Current Employer (men and women age 25 and older)

	Years of continuous employment				
	Total	1 or less	2-9	10-19	20 or more
Men	100.0	18.0	42.2	23.2	16.7
Women	100.0	23.4	50.8	19.1	6.7
Total	100.0	20.3	45.9	21.4	12.3

SOURCE: Paul O. Flaim, "Work Schedules of Americans: An Overview of New Findings," *Monthly Labor Review*, vol. 109, No. 11, November 1986, p. 4.

Under current practices, workers often receive little notice of impending layoffs, which increases their sense of powerlessness. Blue-collar workers receive an average of 7 days notice of plant closing, and white-collar workers an average 15 days; unionized blue-collar workers receive an average of 2 weeks, while blue-collar workers in non-union establishments receive an average of only 2 days.[89] With such short notice, it is not unusual for workers to face extended periods of unemployment—which vary among different industries—before securing another job, during which time they may lose all unemployment and health benefits that were associated with their previous job. As a recent OTA study concluded, "Notice periods this brief do not allow time to prepare an effective program of adjustment assistance for the displaced workers."[90]

On the whole, little of the growing variation in work schedules appears to be voluntary. For example, the percentage of women working involuntarily part-time increased 300 percent between 1967 and 1984.[91] In October 1986, 23 percent of men and 17 percent of women working part-time reported that they would prefer full-time work—percentages that have grown sharply during the past 10 years.[92]

Accepting part-time work can mean real economic hardship. Part-time workers earn an average of $4.50 per hour compared to $7.80 per hour for full-time workers, while receiving far fewer benefits. Moreover, more than 19 percent of women working involuntarily part-time lived in households below the poverty level in 1983, up from 13.4 percent in 1979.[93]

The factors that have led to part-time work also create a situation where many people put in extremely long hours. Figure 11-15 demonstrated significant growth among people working more than 49 hours per week, and among women working from 41 to 48 hours. At the same time, moonlighting in a second job—or in several jobs—has reached record high levels. The moonlighting rate among women doubled between 1970 and 1985.[94]

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[89] U.S. Congress, Office of Technology Assessment, *Plant Closing: Advance Notice and Rapid Response—Special Report*, OTA-ITE-321 (Washington, DC: U.S. Government Printing Office, September 1986); U.S. General Accounting Office, "Plant Closings: Information on Advance Notice and Assistance to Dislocated Workers," Washington, DC, 1987.

[90] *Plant Closing: Advance Notice and Rapid Response—Special Report*, op. cit., footnote 89, p. 1.

[91] E. Applebaum, op. cit., footnote 26. While the ranks of all involuntary part-time workers have declined slightly since 1983, current levels are historically high (5.3 million in 1986 v. 4 million in 1980); the U.S. Bureau of Labor Statistics indicates that there is normally a much greater decline two to three years into a recovery. See Richard L. Worsnop, "Part Time Work," *Congressional Quarterly's Editorial Research Reports*, vol. 1, No. 22, June 12, 1987, p. 291.

[92] U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, vol. 33, No. 11, November 1986, p. 17.

[93] E. Applebaum, op. cit., footnote 26.

Flexible work hours ("flex-time") have been encouraged by the Federal government,[95] while 4 of every 10 American employers have implemented programs that give workers the freedom to change the time at which they arrive and leave from work.[96] For example, Intel, a company of 21,500 employees located in California's Silicon Valley, has created a "flexible work program," in which temporary workers agree to adjust their hours according to the firm's needs (anywhere between 0 and 40 hours per week, at an expected average of 20 to 25) in return for partial benefits.[97]

Volatility of work schedules can translate into volatility in income. The ability to change jobs results in opportunities for growth and higher income as well as opportunities for failure. A study following 5,000 families during the 1970s found extremely high rates of both upward and downward movement in income. Dividing household incomes into five categories, 23.2 percent moved at least two categories during the decade, and 36.8 moved at least one. Only 40 percent remained in the same relative income position. While more than 71 percent of the white men working in relatively low-paying occupations (clerical and sales, unskilled labor, and non-union operatives in non-durable manufacturing) had moved into higher-paying occupations during the decade, only 40 percent of the black males had done so.[98]

Job Satisfaction and Alienation

Perhaps the most important gap between expectation and reality in the emerging U.S. economy may exist in an aspect of employment that is difficult even to describe, much less quantify. One of technology's most important contributions to the work force is its ability to make work a source of interest and pleasure, rather than one of drudgery and exertion. The work place can be a part of a pleasurable society, and can provide a sense of worth and accomplishment.

Expectations in jobs are as varied as people themselves. Empirical analysis of this subject is limited, and necessarily somewhat vague. Most people would describe a "good" job as one that offers opportunities for learning, creativity, autonomy, and variety.[99] New production networks have the potential to improve many jobs measured on all of these factors. Of course, not everyone would find increased interest and challenge at work a mark of progress. Some people prefer impersonal, routine tasks that do not follow them home—tasks that may involve their hands but not their minds, freeing them for conversations at work.[100]

People also want an opportunity to see and evaluate the results of their individual contributions. While most workers resent intrusive monitoring by supervisors, they may enjoy an opportunity to measure the quality of their own work.[101]

While statistics available from polls are ambiguous (see table 11-12), it appears that at least half of U.S. workers look on employment as both a source of money and a basic expression of self worth. Unfortunately, it is not possible to tell what percentage of the labor force would respond in this way if it were clear that technology could make jobs more interesting, or if increased flexibility in working hours could minimize conflicts between work and raising children; as table 11-12 shows, nearly one-third of the individuals responding to one poll did claim that they would consider a cut in pay in return for more interesting work. There was near-unanimous agree-

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[94] John F. Stinson, Jr., "Moonlighting by Women Jumped to Record Highs," *Monthly Labor Review*, vol. 109, No. 11, November 1986, p. 23. See also John D. Owen, *Working Hours* (Lexington, MA: Lexington Press, 1979).

[95] U.S. Congress, General Accounting Office, "Alternative Work Schedules for Federal Employees," GAO/GGD-85-63, Washington, DC, July 19, 1985.

[96] U.S. Department of Labor, Bureau of Labor Statistics, "BLS reports on Employer Child Care Practices," news release No. 88-7, Jan. 15, 1988.

[97] *Plant Closing: Advance Notice and Rapid Response—Special Report*, op. cit., footnote 89, p. 11.

[98] Greg J. Duncan, op. cit., footnote 87, table 4.5; and University of Michigan, Institute for Social Research, "Five Thousand U.S. Families—Patterns of Economic Progress," vol. 1, 1984.

[99] J.R. Hackman and G. Oldham, *Work Redesign* (Santa Monica, CA: Goodyear Publishing Co., 1980); and J.R. Hackman, J.L. Pearce, and J.C. Wolfe, "Effects of Change in Job Characteristics on Work Attitudes and Behaviors, A Naturally Occurring Quasi-Experiment," *Organizational Behavior and Human Performance*, vol. 21, pp. 289-304.

[100] Katzell, Yankelovich et al., *Work, Productivity, and Job Satisfaction*, The Psychological Corp., 1975.

[101] *The Electronic Supervisor*, op. cit., footnote 20, p. 56.

Table 11-12.—The Rewards of Working

Question:	Response
It is personally important to work?(a)	88 percent answered YES
"I have an inner need to do the very best I can, regardless of pay."	Answering YES 63 percent of college graduates 48 percent of high school graduates 52 percent average
Would you take a cut in salary for more meaningful and interesting work?	32 percent answered YES
Is your main interest in work earning money for other things?(a)	7 percent answered YES
"Most people get their real satisfaction from their home life and their leisure, not their work."	51 percent union leaders DISAGREE 62 percent management DISAGREE
"I find my work interesting but I wouldn't let it interfere with the rest of my life."(a)	21 percent answered YES
"The hue and cry about mounting job dissatisfaction is an invention of professors, journalists, and the 'left'." (b)	80 percent union leaders DISAGREE 71 percent management DISAGREE
Management's concern for the welfare of their employees improves productivity.(b)	86 percent union leaders AGREE 82 percent management AGREE

SOURCES: (a) Harvey Lauer, *Jobs in the 1980s and 1990s: A Sourcebook for Policymakers*, Aspen Institute, Queenstown, MD, June 1983.
(b) Katzell, Yankelovich, et al., *Work, Productivity, and Job Satisfaction*, The Psychological Corp., 1975.

ment that the productivity of the workplace depended heavily on management's concern for their employees.

Occupational Health and Safety

An obvious measure of the quality of American jobs is the extent to which they provide an environment that minimizes the risk of injury and disease. While fatalities and injuries directly traceable to work are responsible for only a small fraction of deaths and sickness in the United States, there is much room for improvement. Over 10 million work-related injuries leading to restricted activity or requiring medical attention occur each year. Of these, approximately 3 million result in lost work time. In 1985 alone, 2 million people suffered disabling injuries on the job, and over 10,000 died.[102]

For the most part, changes in economic structure have improved the safety of working conditions. While the correlation between safe jobs and areas of strong growth is not strong, jobs are increasing where the risks of accidents are comparatively low (see table 11-13). Automated equipment can be substituted for some of the most hazardous work: robots replace human paint sprayers, and automated weaving equipment reduces exposure to particles that cause "brown lung." This was done in part to comply with new occupational health and safety regulations. Taken together, such effects appear to have reduced injury rates more than 30 percent since 1972.[103]

Tracing the impact of economic change on workplace safety is an uncertain business. Data collected on deaths and injuries resulting from work can be unreliable. Accident rates are affected by demographics (younger, less experienced workers tend to have more accidents), business cycles (injury rates increase when high employment rates bring inexperienced people into new jobs and lead to more overtime), changes in the way safety regulations are enforced, and a variety of other factors than can mask the effects of structural change in the economy.[104] Rapid changes in production technology increase the difficulty of ensuring safety conditions. Production processes may become obsolete before they can be shown to expose workers to hazards.[105]

The emerging structure of the U.S.economy may add new kinds of risks. Stress resulting from working conditions has become a major health hazard,[106] resulting in stress-related absenteeism and medical expenses that may cost between $50 and $75 billion annually.[107] In addition, alcoholism and drug abuse may be related to job-induced stress. The National Institute on Drug Abuse has estimated that U.S. firms lose $33 billion per year due to employee drug abuse.[108]

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[102] U.S. Bureau of the Census, *Statistical Abstract of the United States: 1987* (107th edition.), Washington, DC, 1986, table 696.

[103] U.S. Congress, Office of Technology Assessment, *Preventing Illness and Injury in the Workplace*, OTA-H-256 (Washington, DC: U.S. Government Printing Office, April 1985), p. 35.

[104] See Ibid.

[105] See R. Howard. op. cit., footnote 11.

[106] R. Arndt and L. Chapman, "Potential Office Hazards and Control," contract report prepared for the Office of Technology Assessment, September 1984, in *Preventing Illness and Injury in the Workplace*, op. cit., footnote 103.

[107] U.S. Congress, Office of Technology Assessment, *Automation of America's Offices*, OTA-CIT-287 (Washington DC: U.S. Government Printing Office, 1985), pp. 300-304.

[108] David W. Hoyt et al., "Drug Testing in the Workplace—Are Methods Legally Defensible?," *Journal of the American Medical Association*, vol. 258, No. 4, July 24/31, 1987, p. 504.

Table 11-13.—The Safest and Most Dangerous Industries
(lost workday cases per year per 100 full-time equivalent jobs (FTEs))

	Lost workday cases in 1984	Percent growth in lost workday cases 1975-84	Percent of all FTEs in 1984	Percent of all growth in FTEs between 1975 and 1984
Security, commodity brokers	0.3	−25%	0.4%	0.2%
Banking	0.7	17	2.1	0.5
Insurance carriers	0.8	33	1.7	0.3
Educational services	1.3	−7	1.7	0.3
Communication	1.4	−7	1.7	0.2
Personal services	1.5	15	1.2	0.2
Pipelines, except natural gas	1.7	6	0.0	0.0
Real estate	2.2	16	1.4	0.4
Business services	2.2	10	4.9	2.5
All private industries	3.7	12	100.0	100.0
Rubber and misc. plastics products	6.4	−4	1.0	0.2
Stone, clay, and glass products	6.6	12	0.8	−0.0
Fabricated metal products	6.7	2	1.9	0.0
Construction	6.9	25	5.7	1.1
Water transportation	7.3	−11	0.2	−0.0
Air transportation	7.5	1	0.6	0.2
Food and kindred products	8.1	11	2.1	−0.1
Trucking and warehousing	9.1	21	1.7	0.3
Lumber and wood products	9.9	16	0.9	0.1

FTE = Full-time equivalent employee.

SOURCES: For injury rates, U.S. Bureau of the Census, *Statistical Abstract of the United States: 1967* (107th edition.), Washington, DC, 1986; for FTEs, U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.7b. FTE.

While uncertainty in the American economy have often been great, pressures can increase in periods of rapid change. Rapid changes in working environments and management practices can lead to stress. Many new office jobs result in increased responsibility without increased authority—a combination that easily leads to stress.[109] Increased use of electronic surveillance equipment may also contribute to stress.[110]

The first part of this chapter documented a dramatic increase in work force participation rates of women, many of whom must combine work with stressful family responsibilities; this, in turn, can increase stress on the job as well. For example, a recent survey of several firms found that roughly one-quarter of employees over age 40 provided care for elderly relatives, and that 80 percent of these providers were women;[111] this has translated into symptoms of depression that are three times higher among the *providers* of eldercare than among the elderly themselves.[112]

Increased numbers of jobs are now found in offices. Until recently, little was known about illness related to an unhealthy indoor environment—now called the "sick building syndrome." Unlike toxic substances associated with industrial settings, Federal safety standards have not yet been applied to indoor pollution. Symptoms are typically vague, including dizziness, drowsiness, and headaches, but can also include such life-threatening diseases as cancer and pneumonia.[113] The problems are often difficult or impossible to trace. Many appear to be tied to tobacco smoke, building fabrics, and copy-machine chemicals.[114] The long term effects are still largely speculative. They are likely to be at least as great as exposure to air pollution outdoors.[115]

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[109] See the discussion of the insurance industry in the Personal Business and Communication section of chapter 12.

[110] See 9-to-5, "The 9 to 5 National Survey on Women and Stress—Office Automation: Addendum," National Association of Working Women, Cleveland, OH, 1984, pp. 4-5; see also *The Electronic Supervisor*, op. cit., footnote 20.

[111] "Issues for an Aging America: Employees and Elder Care," University of Bridgeport, Center on Aging, Bridgeport, CT, 1987.

[112] University of Michigan, School of Nursing, cited in Fairlee Winfield, "Workplace Solutions for Women Under Eldercare Pressure," *Personnel*, vol. 64, July 1987, pp. 31-39.

[113] Hal Levin, "Indoor Air Pollution and Its Applications in Office Building Development and Operation," in J. Thomas Black et al., ed., *The Changing Office Workplace*, The Urban Land Institute, Washington, DC, 1986.

[114] Robert Steyer, "Sick-Building Syndrome," *Across the Board*, December 1986, p. 35.

Asbestos exposure in buildings also presents a serious problem in some areas. While the removal of asbestos from schools has been given much attention by the Federal government during the past decade, States have had to shoulder most of the burden of addressing the 733,000 public, commercial, and large residential buildings that are estimated to contain the substance.[116]

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[115] Hal Levin, op. cit., footnote 113.

[116] U.S. Environmental Protection Agency, cited in Rochelle L. Stanfield, "Abating Asbestos," *National Journal*, vol. 19, No. 43, Oct. 24, 1987, p. 2704.

Chapter 12

Work and the Amenity Networks

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Chapter 12

Work and the Amenity Networks

While chapters 10 and 11 chronicled massive changes taking place in the working life of most Americans, many of the changes proved difficult to explain. The present chapter attempts to explain some of these changes by examining the way the structural shifts described in chapter 6 affect the nature of work in each amenity network.[1]

It proves to be easier to document the kinds of jobs that are disappearing than the kinds being created by economic change. The number of jobs in traditional occupations like machine operators, farmers, and secretaries is declining while there has been rapid growth in jobs classified as "other." The problem of tracking shifts in occupations is made all the more difficult by the fact that many careers have become serial specialties. Few people can expect to begin a career with a long apprenticeship and end it with a gold watch. Employers are likely to find that the most valuable employees are those with protean characteristics—people capable of shifting rapidly to new tasks and teaching themselves what needs to be known. Typically, this requires an ability to work as a part of a group that often combines disparate backgrounds and capabilities. The right kind of education can provide employees with considerable scope. Given no other information, it is often difficult to determine whether a person staring at a computer screen is operating a nuclear power plant or answering a consumer's inquiry about a credit card charge.

FOOD

Over 17 million people owe their jobs directly or indirectly to food production, processing, preparation, and sales. This is roughly 16 percent of all U.S. jobs. Of this total, one out of five work preparing foods, largely in restaurants (see figure 12-1). Food production provides nearly as many jobs for data entry employees as for farmers.

Productivity growth in this network has been uneven. Rapid growth in on-farm productivity and steady advances in food manufacturing technology have resulted in declining employment in these areas. Comparatively slow productivity growth among grocery stores, restaurants, and wholesale facilities, coupled with rising demand, has resulted in rapid job growth. There is a real danger that structural changes underway in food production will result in an industry sharply divided by skills and wages.

Farming

Although farms employed one-third of the U.S. work force at the end of the 19th century, there were only about 3 million people working on farms in the United States in 1986. The farm jobs that remain are likely to fall into two categories: (i) jobs for managers and skilled equipment operators whose wages and skills will more closely resemble those in advanced manufacturing firms than those in traditional farming; and (ii) poorly paid, temporary and often dangerous jobs for unskilled farm labor.

The fate of the much celebrated "family farm" remains clouded. Some, of course, can and will grow to become major production operations. Others will be maintained even at very low rates of return on assets by farm families willing to sacrifice income for the independence and dignity of farm life. Increasingly, this independence is available only for those able to supplement farm income with income from other sources. Of roughly 2.2 million farms operating in 1982, only 860,000 were operated by individuals who reported no off-farm income. More than one-third of the operators worked more than 200 days a year in off-farm occupations.[2] Taken as a

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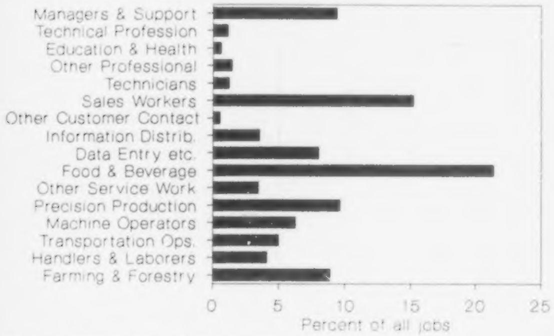
[1] As with chapter 6, the amenity discussions in the present chapter are drawn largely from a set of working papers conducted in support of this document; since the papers were cited in the appropriate sections of chapter 6, citations are not reproduced here. Also in keeping with the form set by the earlier chapter, this discussion concludes with a look at the U.S. manufacturing sector as a whole, though many manufacturing activities are addressed by the individual amenity discussions.

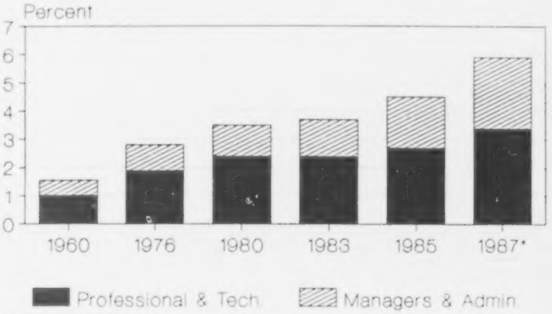
[2] U.S. Bureau of Census, *1982 Census of Agriculture*, Washington, DC, October 1983.

Figure 12-1.-Jobs Needed To Produce Food in 1984 (percent of 17.5 million jobs)



SOURCE: See table 10-6 of chapter 10.

Figure 12-2.-Professional, Technical, and Managerial Positions in Agriculture as a Percent of all Jobs in Agriculture



*November 1987.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, matrices for Employment by Occupation and Industry, Washington, DC, various years.

whole, farms with annual sales below $40,000 (71 percent of all farms operating) failed to make any net income in 1985.[3] Farming enterprises with annual sales above $500,000 (1.2 percent of all farms) were responsible for 55.3 percent of all net farm income in 1985, and are expected to provide more than 80 percent of all farm output by the turn of the century.[4] These large farms are typically managed like modern production facilities (see figure 12-2).

While growing farm productivity will eliminate many jobs, it appears that there will be continuing need for the services of farm laborers. There are presently 2.6 million hired farm workers, of whom 740,000 work more than 150 days a year.[5] New technologies may substitute for some stoop labor in areas such as fruit harvesting, but reliable estimates are difficult to obtain. It does appear that these workers are the most glaring exception to cheerful estimates showing how machinery has substituted for difficult and dangerous work. In 1985, employees in agriculture, forestry, and fishing enterprises were nearly five times more likely to suffer a death on the job than the average U.S. employee.[6] The continued availability of individuals willing to work seasonally for very low wages, and the alternative of inexpensive produce from abroad, diminishes incentives to introduce technology and capital equipment as a substitute for migrant farm labor.

Food Manufacturing

The food manufacturing work force has been decreasing in absolute numbers because labor productivity has grown faster than demand for the output of food in domestic facilities. Total employment in food and kindred product manufacturing fell from 1.83 million in 1955 to 1.65 at the end of 1987.[7] The beef and pork industries, which have labor costs that exceed the average for all food manufacturers, have made major efforts to reduce such expenses. Productivity gains made possible in part by centralized processing of boxed beef described in chapter 6 caused the number of meat cutters and butchers to decline an average of 1.2 percent annually between 1970 and 1982.[8] Partial automation in centralized facilities has had the effect of narrowing tasks and reducing skills.

Mechanization has also eliminated some of the heavy lifting and other hazards of cutting, though meat cutting remains a highly dangerous occupation. Food processing is still one of America's most dangerous industries, with the second highest rate of occupational injuries and illnesses per full-time worker.[9]

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[3] U.S. Bureau of the Census *Statistical Abstract of the United States: 1987* (107th edition.), Washington, DC, 1986, table 1114.

[4] 1985 statistics from Census Bureau, cited in footnote 3. Forecasts from Office of Technology Assessment, *Technology, Public Policy, and the Changing Structure of American Agriculture*, OTA-F-285 (Washington DC: U.S. Government Printing Office, March 1986).

[5] U.S. Department of Agriculture, Economic Research Service, "The Hired Farm Working Force, 1983" AER-554, Washington, DC, June 1986.

[6] *Statistical Abstract of the United States: 1987*, op. cit., footnote 3, Table 696.

[7] U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, various issues.

[8] U.S. Department of Labor, Bureau of Labor Statistics, *Employment Projections for 1995* Bulletin 2197, Washington, DC, March 1984, p. 48.

Retailing and Wholesaling

Retail and wholesale food stores (primarily groceries and their suppliers) provide at least as many jobs as farming. In 1985, retail groceries employed 2.6 million persons and wholesalers 670,000. Some of the best paid employees in the American food production and delivery system work in grocery stores; high levels of unionization have held wages considerably above retail averages. This situation is changing rapidly as employers attempt to drive down labor costs.[10]

The impact of new information technologies on employment will be more indirect. While they will increase the productivity of cashiers somewhat, much check-out work will remain labor-intensive. Technology will have its greatest effect on the clerical jobs associated with taking orders, processing invoices, preparing announcements, handling promotional coupons, making sales calls, and correcting errors in all of these processes.

The negotiating status of grocery employees has been undermined by declining employment in beef preparation—a job requiring a unique and specialized skill. Chicken and pork preparation has been almost completely removed from retail grocery firms —replaced with centralized processing and brand-name products. Beef preparation may follow. Continued movement of meat cutting into factory settings, however, is by no means certain. Some up-market stores have rehired butchers primarily for promotional reasons (see p. 209).

Management has taken advantage of soft labor markets to be much more aggressive in opposing unions. In a widely reported case, Kroger, the Nation's second largest retailer, closed a large number of operations in Pennsylvania because it claimed that union wages made it uncompetitive.[11]

These strategies have had a striking effect on wages and work hours. Grocery wages are now declining and retail labor's share of the food dollar actually decreased 3.5 percent in 1985.[12] Part-time workers are replacing full-time workers; hours per week in grocery stores fell from 32.5 in 1977 to 30.6 in 1983. At the end of 1983, average weekly earnings in grocery stores were nearly equal to the average weekly earnings of all private workers and were 37 percent higher than the earnings of average retail workers. By the end of 1987, average weekly earnings in groceries had fallen to 78 percent of the average for all private workers and were only 15 percent higher than average retail wages. Jobs in grocery stores may increasingly resemble conventional retail jobs in both the skills they require and the wages that are paid.[13]

Food Services

Restaurants and other food service businesses have been a major source of new jobs in the United States. Most of these jobs pay very low wages, and provide only part-time work. In October 1987, the average worker in an eating and drinking place worked 25.9 hours a week (down from 35.5 hours in 1960) and earned $4.44 an hour (a wage less than half the national average).[14] The difference between restaurant employment and jobs elsewhere in the economy may become even more exaggerated as automated equipment substitutes for routine skills in many facilities, and the management of a fast food franchise is made much easier by the introduction of sophisticated computer-based inventories and accounting information that can be derived directly from check-out registers.

Food service employees not only work part-time, but typically work hours that would not be attractive if alternatives were available. Restaurant employees often work in the evenings and on weekends. Low wages make the jobs unattractive to anyone forced to commute any significant distance. A commute costing $5 could reduce take-home pay by 20 percent.

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[9] U.S. Bureau of Labor Statistics, *Occupational Injuries and Illnesses in the United States* cited in *Statistical Abstract of the United States: 1987*, op. cit., footnote 3, table 697.

[10] Charles R. Handy, "Food Retailing," in *Food Marketing Review, 1986*, AER-565, U.S. Department of Agriculture, Economic Research Service, Washington, DC, February 1987.

[11] P.R. Kaufman, "Food Retailing," in *Food Marketing Review, 1985*, U.S. Department of Agriculture, Economic Research Service, Washington, DC, 1986.

[12] R. Parlett and D. Dunham, "Food Prices Post Small Rise," in *National Food Review*, Report No. 32, U.S. Department of Agriculture, Economic Research Service, Washington, DC, 1986, p. 17.

[13] U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, various issues.

[14] U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, vol. 34, No. 12, December 1987, p. 95.

Fast-food service was made possible in part by the fact that many young people were willing to work irregular hours for low wages. The industry may face difficulties as the number of entry-level workers declines for demographic reasons (see ch. 11). Retired workers may be a new source of labor for the industry. Food chains such as McDonald's and Wendy's have already started to hire senior citizens to compensate for a shortage of teenagers.[15]

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[15] Terry Stephenson Supple, "The Coming Labor Shortage," *American Demographics*, vol. 8, No. 9, September 1986, p. 34.

HEALTH

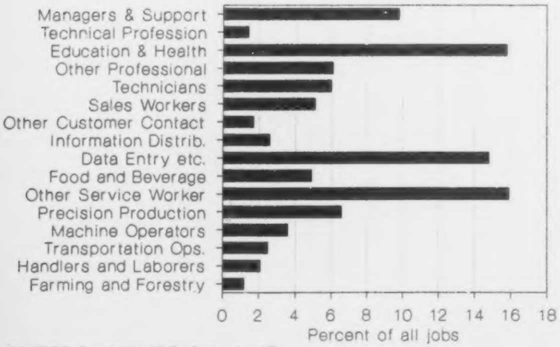
Bringing the Health amenity to Americans requires the efforts of about 14 million people. The range of talents required is enormous. Health enterprises employ large numbers of professional personnel, technicians, as well as semi-skilled personnel (see figure 12-3). The extraordinary amount of paperwork associated with health care in today's economy is evident from the fact that Health spending produces nearly as many jobs for data entry personnel as it does for education and health professionals.

The Future of Health Care Employment

Factors Affecting Supply and Demand

As recently as 1983, estimates provided by the U.S. Bureau of Labor Statistics (BLS) suggested an overall increase of 3 million new health care jobs between 1982 and 1995—almost 12 percent of all new jobs created.[16] Although these numbers suggested a slight slowing of the growth in health care employment that was experienced during the 1970s, they did not fully reflect the profound changes that were beginning to occur in the early 1980s. Table 12-1 shows an uneven pattern of growth. There has been a rapid and continuing rise in the more highly skilled medical professions, but comparatively slow growth among licensed practical nurses and other "health technicians." The number of these technicians actually declined in 1987. The table, of course, does not include many people indirectly employed by health enterprises.

Figure 12-3.-Jobs Needed To Produce Health in 1984 (percent of 13.9 million jobs)



SOURCE: See table 10-6 of chapter 10.

Significant changes underway in the structure of the Nation's health care network will have profound effects on the nature and number of jobs created in this system. Employment in health services will shift away from the hospital. New jobs will be created primarily in smaller, ambulatory care facilities, nursing homes, and home health agencies. Jobs within the hospital setting will also change in response to new technologies and management strategies. The following themes will dominate:

- The combination of an increase in the supply of physicians[17] and growth in the number of investor-ownership of hospitals and ambulatory facilities may result in a greater proportion of physicians and other health practitioners becoming salaried employees of health care corporations.[18] As a result, physicians' wages may decline or stabilize.
- Conflicting forces will affect growth in occupations sometimes known as physician "extenders" —such as physician assistants, nurse practi-

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[16] G.T. Silvestri, J.M. Lukasiewicz, and M.E. Einstein, "Occupational Employment Projections Through 1995," *Monthly Labor Review*, vol. 106, No. 11, November 1983, pp. 37-49; and U.S. Department of Labor, Bureau of Labor Statistics, "Employment Projections for 1995," Bulletin 2197, Washington, DC, 1984.

[17] In 1981, on average, only 36.9 percent of physicians were over 50 and 41.4 percent were under 40. See American Medical Association, "Profile of Medical Practice, 1981," Chicago, IL, 1981.

[18] D. Neuhauser, "Twenty-First Century Medicai Education: Economic, Social, Political and Technological Implications for Change," presented at the 94th Annual Meeting of the Association of American Medical Colleges, Washington, DC, 1983.

Table 12-1.—Health Related Occupations

	Number of jobs (in thousands)		Percent women	Annual percentage growth rate in numbers	
	11/83	11/87	11/87	11/83-11/87	11/86-11/87
Health diagnosing	706	826	18.1	4.00	9.0
Health assessment	1,909	2,118	85.1	2.63	7.6
Health technologists	1,113	1,173	83.7	1.32	−0.6
All occupations (for reference)			45.1	2.52	2.8

	Average hourly earnings (percent above/below national average)	
	1983	10/87
Offices of physicians	−10.2	−7.3
Hospitals	1.7	9.7
Nursing homes and personal care	−35.3	−33.5

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, Tables A-22 and C-2, various issues.

tioners, mid-wives, and nurse anesthesiologists. Pressures to contain costs would seem to favor the substitution of low-wage personnel to perform certain physician tasks. However, the growing surplus of physicians may make it harder for physician extenders to gain entry into the field.

- Although hospital utilization is declining, demand for registered nurses is increasing, in part because many of the people admitted to hospitals require more care. A real nursing shortage has resulted in some regions. There are a variety of explanations, the most compelling being comparatively low wages and irregular working hours offered nurses coupled with the growing number of attractive alternative employment opportunities for women with comparable education and training.[19] More nurses are likely to obtain BAs, MAs, and even doctorates.[20] The nursing profession may become increasingly polarized between highly skilled jobs in acute care hospitals and general duty nursing jobs in ambulatory and convalescent care facilities and home care settings.
- Hospital-based employment for licensed practical nurses is also likely to shift towards convalescent and home health care.
- The number of positions for health care managers and administrators will continue to grow.[21] Traditionally these workers were doctors or nurses, but today the vast majority are graduates of health care administration, public health, or business programs.
- Demand for medical technicians with different specialties is sensitive to the nature of the equipment used in health care. Demand also depends on where the technology is used (much equipment is now used away from the hospital).[22] Demands for comparatively high levels of training are likely to increase since it is very likely that new equipment will be the rule rather than the exception. Technicians and assistants unable to keep abreast of fast moving changes in technology may find employment opportunities shrinking because of automation.
- Health care workers with comparatively few formal skills, such as nurses' aides, orderlies, and attendants, constitute about 40 percent of the health work force. These jobs are likely to shift from hospitals to convalescent and home care settings.
- Increasing application of information and communications technologies to health care delivery can have significant effects on the nature

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[19] L.H. Aiken and C.F. Mullinix, "The Nurse Shortage: Myth or Reality," *The New England Journal of Medicine*, vol. 317, No. 10, 1987, pp. 641-646; J.K Inglehart, "Problems Facing the Nursing Profession," *New England Journal of Medicine*, vol. 317, No. 10, 1987, pp. 646-652.

[20] U.S. Department of Health and Human Services, Health Resources Administration, "Source Book—Nursing Personnel," DHHS Publication No. HRA81-21, Washington, DC, September 1981.

[21] From 1980 to 1982, the number of health administrators grew from 213,000 to 228,000. See U.S. Department of Labor, *Handbook of Labor Statistics 1983*, Bulletin 2175, (Washington, DC: U.S. Government Printing Office, 1983).

[22] U.S. Department of Labor, Bureau of Labor Statistics, "Medical Technology of the 1980s: Giving Birth to New Health Careers," *Occupational Outlook Quarterly*, vol. 27, No. 1, winter 1983, pp. 3-14.

of work in health profession. For nurses, computer technologies can reduce the time spent performing clerical duties and increase the time available for direct patient care. Complex medical care technologies can create nursing specialties, as is now seen in intensive care units. Home health care employment may be more highly skilled, due to earlier hospital discharge and new telemedicine capabilities. Computer-aided diagnosis and treatment technologies could result in greater job responsibilities for non-physician providers, and in perceived deskilling of physicians. At the same time, however, consumer use of these technologies could reduce the need for health care providers of any kind.

- Since 13 percent of health care workers are minorities, as compared to 10 percent in the rest of the labor force, and since the overwhelming majority of health care employees are female, reductions in hospital employment due to layoffs or closures will significantly affect these groups—particularly in depressed urban centers. In addition, many current health workers may also be displaced if jobs that remain in the hospital require an upgrading of skills through tougher requirements or longer training periods (e.g., a BA for RN licensing).

Wages in Health Services Delivery

The earnings of wage and salary workers in the many health service occupations are below average (again see table 12-1). Some increase has occurred in the past few years, but progress has been comparatively slow.[23] There are at least three reasons for estimating continued low average wages in the sector:

1. The proportion of women in the health services delivery sector is high, and will remain so in the future. While women constituted 45.1 percent of the national labor force in December 1987, table 12-1 shows that they accounted for 85 percent of all employment in health assessing occupations and 84 percent of all health technologists. Women typically are paid only 70 percent of men's earnings (see discussion in ch. 11).
2. The growth of largely non-unionized proprietary health care chains, and the growth of contracting out for health services—as evidenced by temporary nursing agencies and laundry services—may circumvent unions and benefit provisions and result in lower wages. Historically, unions have been able to win wage and benefit increases from hospitals for the 15 to 20 percent of the health labor force that is unionized, most of whom are lower-skilled workers. The union pay advantage typically amounts to approximately 5 percent for nurses and 10 percent for lower-skill workers.[24]
3. The shift in employment from the hospital to ambulatory care facilities may also result in a lowering of wages, particularly for nurses. In 1980, nurses in hospitals earned approximately $4,500 more than nurses employed in physicians' offices.[25] Employees in the rapidly growing home health care business are often paid extremely low wages.

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[23] E. Sekscenski, "The Health Services Industry: A Decade of Expansion," *Monthly Labor Review*, vol. 104, 1981, pp. 9-16.

[24] F. A. Sloan and B. Steinwald, *Hospital Labor Markets: Analysis of Wages and Work Force Composition* (Lexington, MA: Lexington Books, 1980); R. Feldman and R. Scheffler, "The Union Impact on Hospital Wages and Fringe Benefits," *Industrial and Labor Relations Review*, vol. 35, 1982, pp. 196-206; and U.S. Department of Labor, Bureau of Labor Statistics, "Industry Wage Survey: Hospitals," Bulletin 2204, Washington, DC, 1984.

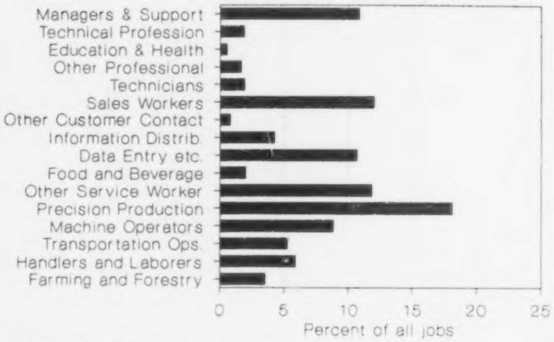
[25] U.S. Department of Health and Human Services, Health Resources Administration, "The Registered Nurse Population: An Overview," DHHS Publication HRS-P-OD-83-1, Washington, DC, November 1982.

HOUSING

The jobs produced to supply Americans with housing and to provide construction services of all kinds are most heavily concentrated in "precision production," a category that includes most building trades (see figure 12-4). The large financing costs of housing described in chapter 6 do not produce a correspondingly large number of jobs in the financial or real estate industries.

The use of labor in the construction industry provides a good example of the ways diverse, multidisciplinary teams can be assembled on short no-

Figure 12-4.-Jobs Needed To Produce Housing in 1984 (percent of 15.8 million jobs)



SOURCE: See table 10-6 of chapter 10.

tice for a variety of projects.[26] Adapting itself to a long history of uncertain demand, the industry has achieved enormous flexibility. Unfortunately, much of this flexibility has been achieved by avoiding long-term commitments in the form of either capital investment or permanent staffs. Most single-family home construction is undertaken by small independent builders with no permanent payroll. Even major projects, such as the construction of a nuclear power plant, typically involve a unique combination of contractors, subcontractors, and temporary personnel.

The price of flexibility appears to have grown in recent years. Labor productivity in construction has actually declined, construction wages have fallen in comparison to national averages, and uncertainty surrounding employment in construction has risen. Capital-to-labor ratios increased 2.6 percent per year from 1947 to 1968, but declined by 3 percent per year from 1968 to 1981. After a jump of 4 percent in 1982, the rate has continued to decline.[27]

New manufacturing technology used in construction could increase capital investment and encourage greater commitment to a trained permanent staff. This could radically transform the employment demands of the industry. A significant amount of work on home construction is already done in factory settings (pipe trees, roof trusses, pre-hung doors, and entire wall panels). This has the effect of moving jobs from the construction site into more manufacturing and designing settings.

Labor Productivity

Real productivity in the construction industry has fallen steadily since 1968, with the exception of certain years. Overall, only mining appears to have suffered a worse decline, but in mining the decline is largely due to increased investment in workplace safety. The decline in construction productivity is particularly perplexing since it is obvious that many new technologies (plastic piping, pre-hung windows, factory-made roof trusses, etc.) have made some parts of the construction process—particularly in the residential sector—more productive (see p. 226).

There is no consensus about why new technologies have not led to higher measured productivity in the construction industry. A variety of explanations have been offered.[28] It is possible that productivity has declined because a highly fragmented industry that has never invested heavily either in research or capital equipment has simply failed to keep pace with technology available in other parts of the economy.[29]

Poor management practices and craft traditions may also contribute. One recent review of major construction practices (both residential and non-residential) estimated that only about 40 percent of a worker's time is spent in productive activity; of the rest, more than half is lost because of administrative delays, poor selection of methods, or jurisdictional delays.[30] Administrative delays result from poor coordination, late deliveries, confusion at the site, and inadequate planning. Many new commercial buildings, for example, use poured concrete; the price of building form-work for the concrete represents half the total cost. Yet architectural drawings seldom indicate how these forms should be designed, and take no account of the complications introduced by imbeds needed for items such as electrical boxes. As one analyst has noted: "Architects love to put a lot of imbeds . . . and you depend on the workers in the field to somehow hold it in exact position while you place the concrete around it and push it around."[31]

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[26] See Michael Piore and Charles Sable, *The Second Industrial Divide* (New York, NY: Basic Books, 1984).

[27] U.S. Department of Labor, Bureau of Labor Statistics, cited in Building Research Board, National Research Council, *Construction Productivity* (Washington, DC: National Academy Press, 1986).

[28] U.S. Congress, Office of Technology Assessment, *Technology, Trade, and the U.S. Residential Construction Industry—Special Report*, OTA-TET-315 (Washington, DC: U.S. Government Printing Office, September 1986), pp. 31-32.

[29] J.E. Cremeans, "Productivity in the Construction Industry," *Construction Review*, vol. 27, May/June 1981.

[30] Richard L. Tucker, "Construction Technologies," in *Technology and the Future of the U.S. Construction Industry* (Washington DC: The AIA Press, 1986).

Jurisdictional problems are not necessarily the result of union work rules, but stem from longstanding craft traditions: "Carpenters don't put in conduit, for example, even though they're quite capable . . . Operators can't unload the truck. It takes a particular craft that has the stuff on the truck to unload their stuff."[32] Estimates of productivity gains made possible through better communication and management practices with *no* new technology range from a few percent for processes such as installing insulation, to 130 percent for structural work in commercial buildings or installing piping in heavy industrial structures.

New technology clearly has the potential to increase productivity throughout the construction industry. Many of the most basic problems in field erection, primarily affecting heavy construction, have received virtually no help from contemporary technology. Making field connections of pipes, beams, electrical wire or other elements is extremely inefficient in the field. The current process "leaves a lot of standing around."[33]

Wall elements, and even entire building modules, have been successfully manufactured in factories to improve overall productivity, particularly in the residential sectors of Sweden and Japan. Much of this improvement has resulted from greater use of factory production techniques based on robotics and computer-assisted design/production systems. The Japanese firm of Sekisui Heim claims to have reduced the labor hours for a residence from 400 person-days for a conventional site-built house to 125 person-days for a manufactured house, and to have an experimental system capable of reducing construction time to 20 person-days. The Swedes, estimate that they can reduce labor from 175 to 75 person-days using factory construction; of the 75, nearly two-thirds are taken up by site preparation and erection.[34]

Productivity in residential construction is also discussed in the Housing section of chapter 6.

Job Skills and Job Quality

Compared with jobs elsewhere in the economy, jobs in construction are traditionally well paid but are relatively dangerous and insecure.[35] A shift toward more factory-based construction could change this picture. The Swedes chose to encourage factory-based construction as a matter of national policy in part *because* it could create better and more stable jobs in the industry.

Wages

While jobs in construction still pay more than the average U.S. wage, construction wages fell from 28 percent above the median annual U.S. private sector wage in 1971 to less than 9 percent above the median in 1986—when the ratio of median annual construction wages to the national average median wage reached a post-war low.[36]

Skills and Work Quality

The Swedes emphasize that their homes are "factory crafted," not mass produced, and that automated equipment is used by skilled teams that have often worked together for years.[37] They do not use "mass production" lines. In Japan, where factory production is projected to serve 50 percent of the domestic market in the mid 1990s, "housing companies apparently enjoy a high level of worker loyalty and productivity."[38]

U.S. factory construction of housing is often little more than site construction under a roof. Assembly of mobile homes ("manufactured housing") is typically more heavily automated, using an assembly line approach resulting in less skilled and more routine jobs. There is often a considerable amount of turnover, particularly during periods of slack demand for housing. Some firms have used manufacturing facilities to replace skilled craft workers with low-wage employees who enjoy little job security. Two-thirds of all jobs in U.S. home manufacturing facilities require less than one year of training; 33 to 40 percent require less than a month.[39]

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[31] Alton S. Bradford, "Computers and Construction, in *Technology and the Future of the U.S. Construction Industry*, op. cit., footnote 30.

[32] Ibid.

[33] Ibid.

[34] Paul Kando, "Perspectives on Swedish and Japanese Factory Built Housing" contract report prepared for the National Institute of Building Sciences, Washington, DC, Nov. 5, 1986.

[35] John Tschetter and John Lukasiewicz, "Employment Trends in the Building Trades," *Occupational Outlook Quarterly*, vol. 27, No. 2, spring 1983, p. 8.

[36] U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.8b.

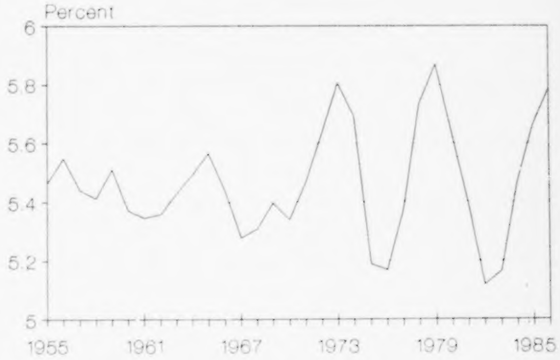
[37] Lee Schipper, Stephen Meyers, and Henry Kelly, *Coming in From the Cold: Energy Efficient Housing in Sweden* (Cabin John, MD: Seven Locks Press, 1985).

[38] James G. Sackett, "Japan's Manufactured Housing Capability," contract report for the U.S. Department of Energy, Washington, DC, May 1986.

Technology also promises to change the use of labor in design and engineering firms. Computer-based designs can radically reduce routine architectural jobs. Each designer is typically supported by 3.8 draftsmen and 0.2 persons engaged in writing specifications and documentation. Most of the individuals calling themselves architects are, in fact, engaged in such support activities.[40] At least one in four jobs in architecture is therefore threatened by new technology. Computer-based designs will also affect engineering draftsmen, who are generally not trained engineers.

Jobs in design and engineering may also change with the introduction of computer-based design systems. Manual tasks can largely be replaced. The staff remaining are likely to be members of interdisciplinary teams consisting of designers, builders, and individuals familiar with the specific needs of a client. Interpersonal skills, and a basic grasp of all parts of the construction process—from design to engineering analysis to site construction—will be needed for members of such teams.[41]

Figure 12-5.-Construction Jobs as a Percent of all Jobs



SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.7.

Job Security

Employment in construction varies with the weather, with the seasons, and with the business cycle. An average annual construction work force of some 4 million varies by as much as one-quarter between winter and summer; this is especially acute in the northern areas of the United States. Approximately 40 percent of U.S. construction workers found themselves without employment at least once during 1981, as opposed to 18 percent of all U.S. nonagricultural workers.[42] The industry has always been very sensitive to changes in the business cycle (see figure 12-5), and this sensitivity appears to have increased during the past few decades.[43]

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[39] *Technology, Trade, and the U.S. Residential Construction Industry—Special Report*, op. cit., footnote 28, table 5.

[40] Harry Mileaf, "Computers and Construction," in *Technology and the Future of the U.S. Construction Industry* op. cit., footnote 30.

[41] A. Bradford, in *Technology and the Future of the U.S. Construction Industry* op. cit., footnote 30.

[42] Ibid., p. 7.

[43] Tschetter and Lukasiewicz, op. cit., footnote 35, p. 5.

TRANSPORTATION

The U.S. transportation system provides starkly contrasting employment opportunities. Some firms, such as major railroads, rely on well-paid management and labor. Skilled operators of large, complex equipment (such as ships, aircraft, and trains) have large responsibilities and are well rewarded. Unions have helped maintain wages. Many transportation firms, however, such as owner-operator truckers and cab drivers, might actually be earning less than the minimum wage if they accounted properly for their hours.

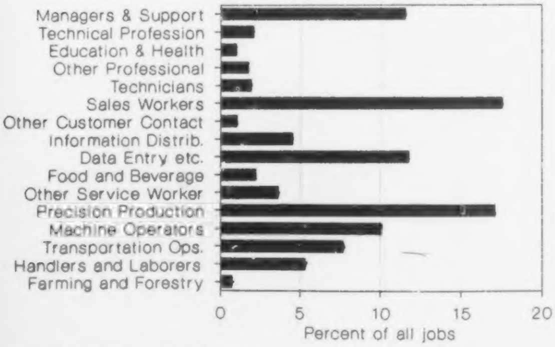
Providing the Transportation amenity produces more jobs in manufacturing and other professions than it does for equipment operators (see figure 12-6). Automobile production results in a large number of well paying positions. The operation of automobiles produces a varying assortment of jobs, including a large number of sales workers ranging from automobile sales personnel to sales workers in gasoline stations paid hourly wages 40 percent below average 1987 wages.

Employment in the industry is strongly affected by changes in demand, production recipes, and trade described in earlier chapters. The decline in highway and airport construction obviously translates into a loss of comparatively well paid construction jobs. Deregulation of trucking and aircraft has created fierce competition, making union organization more difficult.

Technologically sophisticated equipment has created demands for higher skill levels in many transportation occupations. Advanced computers and communications equipment are becoming standard in airport control towers. Modern aircraft have become machines of staggering complexity. Railroads, trucking firms, and urban delivery vehicles are keeping close touch with their vehicles using a variety of communication devices. All of this equipment must be designed and maintained, and operators must develop skills to use them properly.

The administrative complexity of transportation is rising as the value and diversity of freight shipments increase. Investments in careful identification of loads within trucks, careful routing and tracking of deliveries, increased insurance, greater use of part-load shipments, and the rapid shift to more complex air transport equipment and facilities all contribute to this diversity. At the same time, new strategies for inventory control are partly responsible for the complexity of transportation information. All of this creates growing demand for clerical, analytical, and technical employees in transportation firms.

Figure 12-6.-Jobs Needed To Produce Transportation in 1984 (percent of 8.1 million jobs)



SOURCE: See table 10-6 of chapter 10.

While technology helps optimize the flow of traffic, individual operators of aircraft, trucks, and other vehicles maintain enormous independence and individual responsibilities. They must not only perform their required tasks competently, but they are the transportation firm's representatives in dealing with customers. This sense of independence and responsibility can make transportation an attractive occupation. While technology can help managers keep closer tabs on the location of vehicles and operator performance, thereby reducing the perception of freedom to some extent, the responsibility for the vehicle's safety and performance remains clear. The skills and responsibility entailed should continue to command comparatively high wages.

Workers in many parts of the transportation industry benefited from public regulation. Public transport workers, railroad workers, and airline employees were particularly advantaged, though trucking regulation sheltered the wages of many drivers in that industry as well.

In a newly deregulated environment, airlines struggling to compete with non-union lines are obtaining concessions from their employees. Truckers are forced to compete with independent, non-union operators who often work long hours and average 30 percent lower wages.[44] Railroads, struggling to meet competition from trucking, have broken some long-standing union work rules, doing such things as running trains with two-man crews. The system is in such flux that industry-wide patterns of employment are extremely difficult to trace.

Employment in most transportation industries has grown more slowly that private employment. Employment in automobile manufacturing is virtually the same as it was in 1955. Transit operators have declined. On the other hand, there has been sharp growth in the airline industries and in service industries that support personal and business transportation. Trucking, warehousing, and wholesale trade have grown modestly faster than overall employment. Many changes are occurring in the kinds of jobs offered by these businesses, however. Employment in regular route common carrier truck firms has not grown, even though overall employment in trucking has increased.

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[44] See U.S. Small Business Administration, *The State of Small Business 1987* (Washington, DC: U.S. Government Printing Office, 1987), pp. 185-206.

Personal Transport

Table 12-2 shows sharp declines in jobs in most mass transportation occupations. Only air travel posted significant gains. Jobs in both inter- and intracity rail and bus transport have remained virtually unchanged. Most local and inter-urban transport facilities are located in older metropolitan areas, such as New York, Philadelphia, Boston, and Chicago. They are heavily unionized, and work rules provide them with relatively stable 8-hour jobs and no split schedules despite the fact that urban commuting requires working two peaks. Moreover, the jobs provide good incomes for employees, many of whom are members of minority groups who might otherwise face bleak job markets in central cities.

In many regions, the provision of attractive employment opportunities in public transport has resulted in high labor costs and increased transit fares. As a result, transit workers in some areas are under pressure to accept part-time or split schedules and lower wages. Many new "paratransit" services benefit from the fact that they can use operators willing to work erratic hours at comparatively low wages in competitive labor markets.

Freight Transport

Two major movements are underway in freight transportation. First, rail lines, operating under increasingly competitive conditions, have placed unprecedented pressures on rail unions to accept greater flexibility in work rules. The results of this development have been mixed. It is clear, however, that unless the work rules are revised in a way that permits rail lines greater flexibility, rail freight will be limited to an extremely narrow set of commodities—typically bulk coal and grain deliveries.

The second movement resulted from the nearly complete deregulation of trucking during the late 1970s, which increased competition between regular route common carriers, independent owner operators, and railroads (particularly in long hauls). These operators may be unaware of their real costs. Many compensate for poor earnings by forcing themselves to drive extraordinary hours. Erratic working hours have, of course, long been necessary adjuncts of truck operation; however, both fatigue and parsimonious maintenance may have contributed to the growing number of trucking accidents (see discussion below).

Table 12-2.—Employment and Employment Growth in Selected Transportation Industries

	Full-time-equivalent employment (in thousands)				Average annual growth rate (%)
Industry	1955	1965	1975	1986	1955-86
All private industries	53,530	57,864	67,443	87,653	1.7
Motor vehicles and equipment	876	831	777	870	0.6
Other transportation equipment	991	1,005	909	1,152	0.1
Railroad transportation	1,196	730	541	311	−3.6
Local and interurban passenger	332	290	282	322	−0.1
Transportation by air	128	221	351	533	4.2
Water transportation	235	218	187	178	−0.8
Pipelines, except natural gas	26	19	17	18	−0.8
Trucking and warehousing	883	1,073	1,249	1,571	1.8
Wholesale trade	3,164	3,648	4,521	5,849	2.1
Transportation services	82	92	137	288	4.3
Auto repair, services, and garages	311	450	638	1,129	4.0

NOTE: Full-time-equivalent employment includes part-time workers converted to a full time schedule using the ratio of the number of average weekly hours worked to the weekly hours typically worked by a full-time employee in the industry. The total also includes self-employed persons. The percentage growth rate is computed using a simple regression.

SOURCE: U.S. Department of Commerce, National Income and Product Accounts, historical diskettes.

If, as chapter 6 suggests, independent truckers eventually lose market share to major companies capable of managing sophisticated marketing, sales, communication, and dispatch systems, many truck drivers may be increasingly treated primarily as paid employees of major firms. Such a development would represent a reversal of the present trend toward small-scale trucking activities brought about largely by deregulation—since 1980, the number of motor carriers with annual sales under $1 million has more than doubled, while those in larger sales classes have held steady or decreased (see ch. 5).

Safety

Transportation jobs are among the most dangerous in the Nation. Death rates are nearly three times the national average. Trucking and warehousing businesses reported losing 208 workdays per 100 full-time-equivalent workers in 1984, up from 188 in 1980. The average for all private businesses in 1984 was 63 workdays lost per 100 full-time workers (a 3 percent decline from 1980). Local passenger transit, railroads, and air transport all reported work losses 40 percent over national averages.[45] While accidents involving passenger cars, motorcycles, and even medium trucks all fell by at least 10 percent between 1980 and 1984, accidents involving light and heavy trucks rose to historically high levels by 1985—even after a significant decrease in such accidents during 1982.[46] Indeed, between 1981 and 1985, the annual rate of truck accidents increased roughly 40 percent faster than the increase in total truck miles traveled.[47]

Transportation jobs can also be extremely stressful. Stress-related illness is seldom reported as an occupational injury, but it is well known that bus drivers have higher rates of hypertension, and of diseases of the gastrointestinal tract and the musculoskeletal system, than other workers. While some of this may be traceable to noise, vibration, and carbon monoxide fumes, some studies suggest that the illnesses are related to the need to keep schedules that are extremely difficult to meet in any but ideal conditions.[48]

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[45] *Statistical Abstract of the United States: 1987*, op. cit., footnote 3, table 697.

[46] Ibid., table 1028.

[47] Statement of Edith B. Page, Office of Technology Assessment, to the Committee on Public Works and Transportation, Subcommittee on Surface Transportation, U.S. House of Representatives, Washington, DC, Sept. 16, 1987.

[48] S.L. Symne "Social Determinants of Health," in *Social Determinants of Health and Disease*, paper provided to OTA by the Centers for Disease Control, Atlanta, GA, p. 65.

CLOTHING AND PERSONAL CARE[49]

The network of fiber, textile, apparel, transportation, wholesaling, and retail businesses that combine to bring the amenity of Clothing and Personal Care to Americans dominates the pattern of jobs shown in figure 12-7. Retailing and machine operators represent 40 percent of all jobs in the network. This may soon change.

The network of businesses that produce fiber, textiles, and apparel combine to be the Nation's largest non-durable goods manufacturer, employing one out of every every nine manufacturing workers. Apparel is the largest employer, with 1.1 million employees at the end of 1987. Textile mills provide 713,000 jobs and organic fiber producers employ 61,000. The textile machinery industry, a durable goods sector, employs 21,000 people. Retail apparel and accessory stores provide jobs for nearly 1 million people. General merchandise stores (which also sell apparel) employ over 2.5 million people.[50]

Growth in domestic demand has partially offset employment losses resulting from increases in imports and productivity. Between 1977 and the end of 1987, employment in the apparel industry fell 15 percent and textile employment fell 19 percent. Total employment fell by 370,000. It is important to note, though, that many of the jobs eliminated by automation were dangerous and unpleasant. The threat of "brown lung" that haunted the industry for

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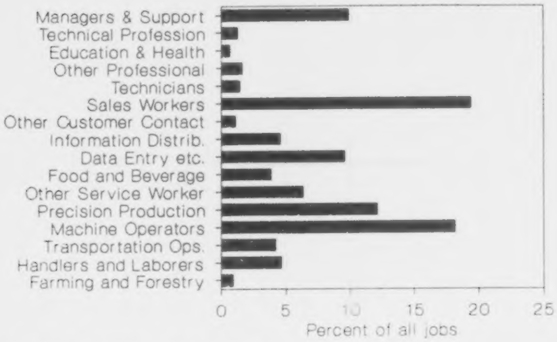
[49] The following section is drawn largely from U.S. Congress, Office of Technology Assessment, *The U.S. Textile and Apparel Industry: A Revolution in Progress—Special Report*, OTA-TET-332 (Washington, DC: U.S. Government Printing Office, April 1987).

[50] U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, vol. 34, No. 12, December 1987, table B-2.

Figure 12-7.-Jobs Needed To Produce Clothing & Personal Care in 1984 (percent of 7.5 million jobs)



SOURCE: See table 10-6 of chapter 10.

years has been reduced significantly through the use of machines for tasks that would pose health and safety threats to human operators.

In apparel, labor-intensive operations still predominate in the industry, and job declines are largely due to import penetration. Women account for 81 percent of apparel employment. The ratio of production workers to total employees was 84 percent at the end of 1987, in comparison to 68 percent for all manufacturing. Job loss has been particularly severe in the apparel industry, which provides large numbers of low wage production jobs for women and minorities.[51]

In textile mill products, adoption of new, capital-intensive technology has resulted in sharply increased productivity. This has led to both job losses and a major redesigning of jobs that remain. Burlington Mills, for example, began a major modernization program in 1978 and has since reduced its work force by at least 10,000. Stevens has spent more than $480 million on its capital program since 1978, and, like Burlington, has trimmed 10,000 people from its payroll. Modernization, of course, does not always lead to job loss—especially if new plant and equipment can be used to expand markets.[52] Indeed, modernization is a crucial element in maintaining any domestic production industry.

The only industry sector claiming new job creation was retail trade. Employment in apparel retailing increased 26 percent between 1977 and the end of 1987, adding 225,000 jobs.[53]

Apparel jobs have traditionally paid lower wages than textile manufacturing jobs—themselves low-paying by U.S. industrial standards. The wages are, of course, much higher than those paid by many of America's competitors. Average 1987 hourly earnings in apparel retail trade were $5.69, in contrast to $6.01 for apparel manufacturing, $7.23 for textile mill products manufacturing, and $8.75 for textile machinery manufacturing. In the newer manmade fiber industry, however, wage rates are significantly higher, with average hourly wages at $12.20.[54] These compare to an average hourly rate for all manufacturing of $10.00.

It is important to note that the United States is not alone in suffering employment losses in the textile and apparel industry. Job loss has occurred throughout the developed world—for example, 53 percent in the Netherlands and 37 percent in the United Kingdom within the last decade. At the same time, employment in developing nations is gaining significantly—111 percent in South Korea and 194 percent in Mauritius, for example.[55]

Domestically, textile employment is geographically concentrated, particularly in the Southeast where plant closings and job loss can mean economic devastation to an entire town or region. In North Carolina, South Carolina, Georgia, Tennessee, Alabama, Florida, Kentucky, and Mississippi, 33,400 jobs were lost in 1985, bringing textile employment 17 percent below its 1951 level. According to the Bureau of Labor Statistics, 32.2 percent of the region's total manufacturing employment in 1951 was in the textile industry. By 1985, this figure had shrunk to only 13.5 percent.[56] The absolute decline in employment has been the greatest in North Carolina, South Carolina, New York, and Pennsylvania.

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[51] *The U.S. Textile and Apparel Industry: A Revolution in Progress—Special Report*, op. cit., footnote 49.

[52] *Textile Week*, Aug. 10, 1981, p. 6.

[53] U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, various issues.

[54] U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, vol. 34, No. 12, December 1987, table C2, pp. 91-93. September 1987 figures used.

[55] International Labor Organization, *Social and Labor Practices of Multinational Enterprises in the Textile Clothing and Footwear Industries*, cited in Bureau of National Affairs, *Daily Labor Report*, Jan. 3, 1985, p. A-6.

[56] U.S. Department of Labor, Bureau of Labor Statistics, cited in *AFL-CIO News*, July 19, 1986, p. 3.

The technology described in chapter 6 has the potential to reshape the jobs offered by the system in very basic ways. Automated equipment—much of it imported—has already revolutionized textile mills and replaced many low-skill, dangerous jobs. Productivity in textile production grew at twice the rate of manufacturing industries during the past decade. Equipment that combines automated inventory control, reordering, design, layout, and other features could lead to a new pattern of work organization, making it possible to substitute highly trained and well paid workers for those now forced into narrow production tasks. Flexibility could be achieved through teams capable of moving quickly to fill new orders and adapt designs to changing markets.

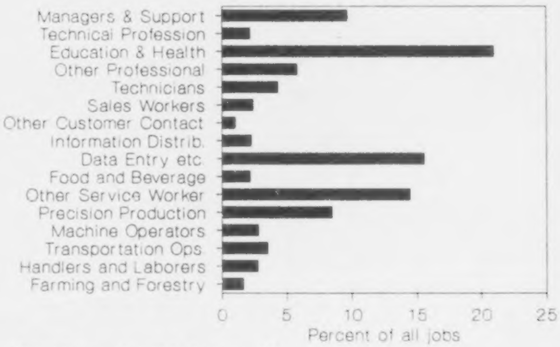
EDUCATION

Productivity

Education is responsible for at least 9 percent of U.S. jobs. This estimate, based on official reports, may underestimate the number of individuals working as teachers or trainers by as much as 50 percent. U.S. corporations obviously make heavy investments in teaching and training, but because people labeled "teachers" are paid relatively low wages, many instructors in a business setting have more expensive sounding titles like "productivity engineer." Earlier discussions also demonstrated that learning and teaching tasks are becoming routine parts of many jobs.

The business of delivering the Education amenity also generates a significant amount of work for clerical and other service occupations (see figure 12-8).

Figure 12-8.-Jobs Needed To Produce Education in 1984 (percent of 9.2 million jobs)



SOURCE: See table 10-6 of chapter 10.

While the productivity of teaching is notoriously difficult to measure, there is little to suggest that it has increased in several generations. Indeed, growth in staff-to-student ratios, coupled with declines in average test scores, suggests that real productivity has fallen. In Japan and Taiwan, it appears that school systems with staff-to-student ratios lower than those in the United States may provide better basic instruction.

Many excuses can be offered for a decline in measured U.S. school productivity.[57] Much of the growth in U.S. staff-to-student ratios resulted from more administrative positions, rather than instructors. Some of the increased overhead costs—but probably not all—result from the need to administer more complex government programs.

Skills and Work Quality

The Work Environment

The occupation "teacher" is one of the largest undifferentiated categories maintained by the Bureau of Labor Statistics. The underlying assumption here is that teachers are largely interchangeable—to some extent the assumption is correct.[58]

The essential difference between teaching and another form of mass delivery, of course, is that there is always something new and exciting about a group of students. The thrill of watching a student discover for the first time a new idea or a great work of art is a reward that cannot be measured by conventional accounts.

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[57] It must be recognized that productivity measurements in education attempt to quantify what is difficult to view in objective terms: the quality of teaching. For example, if two teachers provide a far better learning experience for the same amount of students than one teacher, is their productivity still lower because of the ratio? Are standardized test scores, which may be biased against certain demographic groups, a true measure of the productivity of teaching? Is productivity low because more attention is being paid to students with special physical, mental, or emotional problems?

[58] There are differences in the skills of individual instructors, but virtually no distinctions are made in either job descriptions or pay except for distinctions based on credentials and seniority. Often the only way to advance in status as a teacher is to become an administrator, which may in part explain the growth in the relative size of school administration activities during the past decade.

On the other hand, many teachers in the United States are expected to cure a growing number of social problems—brought on, in part, by the shrinking proportion of traditional families. Different interest groups expect schools to indoctrinate students in everything from religious beliefs to sexual hygiene. Teachers have been sued for exercising both too much and too little discipline. Such pressures can lead not only to frustration, but in some cases to real physical danger.

Specialization and Differentiation of Occupations

Most educational institutions are managed in a way that gives individual instructors almost unlimited freedom in the conduct of instruction within their own domains. Yet, as in so many other cases throughout the economy, unlimited freedom does not necessarily translate into diversity or innovation. Observers have noted that instruction in high schools is astonishingly uniform throughout the country. A system that appears to be highly labor-intensive, thereby permitting much individual attention and flexibility, is in fact often impersonal and inflexible.

An educational work environment making heavy use of new instructional technologies, such as the one described in chapters 3 and 6, could be significantly different from the current system. Schools have already seen some growth in the use of instructors working on specialized problems: teaching the physically or mentally handicapped is one such example. This specialization can be expected to grow enormously with use of new technology. At a minimum, teaching staffs could be divided into the following kinds of specialties:

- tutors trained in professional areas such as chemistry or English literature, who would work with individuals on a daily basis, coach them as they work through problems, monitor their progress in the programmed instructional systems, and challenge them to debate;
- specialized consultants, who would work with students over a wide geographic area, handling questions or problems that individual tutors felt incompetent to address;
- people specializing in the preparation of software that would include computer programming, and in the preparation of visual and audio materials for presentation (which could include animation, simulations, or even complete reenactments of historical events);
- system monitors, paid to maintain order when students are working with information-based systems and to handle routine problems; and
- specialists in the production and maintenance of hardware in the schools, and central distribution and communication modes.

This greater differentiation would plainly lead to differentiation in training and pay. Individuals designing and maintaining the software would necessarily be peers of software design teams working elsewhere in the economy. Teachers would have to make the transition to the more demanding task of tutors, which would require them to spend virtually all of their time handling unique and difficult questions. But teachers exasperated by routine assignments would find themselves much freer to experiment with new ideas and enjoy the company of their students. Any attempt to introduce differentiation in job descriptions may, however, be resisted by unions interested in maintaining a uniform professional position on issues such as pay, seniority, and working conditions.

Wages and Part-Time Work

Teachers are among the best educated class of workers in the market, but are paid significantly less than the average wage. And while there are exceptions, most teacher salaries have not kept pace with inflation.

Measured in constant 1983-84 dollars, the salaries of teachers actually fell from a high of $24,194 in the 1972-73 school year to $20,733 in 1980-81; recent interest in educational reform raised average teaching salaries to $22,019 in the 1983-84 school year.[59] In 1981, about 30 percent of all public school teachers received pay for some form of employment other than teaching to supplement their income.[60]

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[59] National Education Association, "Estimates of School Statistics 1983-1984," Washington, DC, 1985.

There is also little opportunity for advancement. Few teachers are able to enjoy significant increases in pay after their first 10 to 12 years on the job.[61] This is all the more difficult to accept since they receive a starting salary that is far below those offered in many other professions requiring college training. The result is that comparatively little difference in the wages paid teachers: 61 percent of all teachers receive between $15,000 and $25,000 in pay.[62]

Teachers, of course, are seldom paid for year-round work, and are left to their own devices to find employment during summer months. Comparatively few teachers can find work during these months in anything but temporary clerical or sales jobs. Many do not work, but spend the time in leisure activities or, in the case of university faculty, doing research needed for promotion or tenure. Teachers are seldom provided office space or significant clerical support services in their schools and, as a result, spend an average of 4 to 5 hours a week working at home.[63]

The Nation's primary and secondary school systems have always been subsidized by women willing to work for low wages because they could find no alternative employment commensurate with their intellectual skills. This, of course, is changing with the dramatic increase in the participation of women in all parts of the labor force.

Educational Demand and the Desire to Teach

The combination of new job opportunities for women, relatively stagnant pay, and deteriorating work conditions in many school systems has resulted in a dramatic decline in the percentage of women choosing to get degrees in education. While roughly 38 percent of women in their first year of college intended to go into education in 1968, this percentage fell to only about 10 percent in 1985.[64] The fraction of males obtaining bachelor's degrees in education fell from 9.5 percent to 6.5 percent between 1971 and 1980.[65] In 1966, when teachers were asked "suppose you could go back to your college days and start over again; in view of your present knowledge, would you become a teacher?," 53 percent said that they certainly would. By 1983, only 24 percent gave a positive response.[66]

There seems little question that developments such as these are likely to lower the quality of teaching in the public school system. Indeed, there is evidence of a critical juncture in the teaching market—in a break from the past, there are likely to be more jobs than prospective teachers over the next 10 years.[67] Moreover, the fraction of education graduates with backgrounds in science or mathematics choosing to enter teaching has fallen. In 1971, 59 percent of all graduates from science teaching programs, and 63 percent of all graduates from mathematics teaching programs, entered teaching. By 1980, the fraction had fallen to between 54 and 55 percent, respectively.[68]

The disparity between teacher salaries in science and mathematics and salaries offered individuals with equivalent education levels is particularly high. The National Science Foundation estimates that 300,000 new mathematics and science teachers will be needed during the next 10 years, a number larger than the total of those now teaching. The problem is aggravated by the fact that the average age of the Nation's science and math teachers is 42.[69]

Overall, as many as 1.3 million new teachers will be needed between 1986 and 1992.[70] Assuming that the demand for new teachers would be met from existing colleges and universities, this would mean that 23 percent of people graduating from college would need to enter the teaching profession during the early 1990s—a fraction far higher than is likely to be attracted to the profession, given recent history.[71] The potential shortage of teachers with adequate training may contribute to demand for technology in the classroom that can make the best possible use of the time of trained teachers.

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[60] National Education Association, "Status of the American Public School Teacher, 1980-1981," Washington, DC, 1982.

[61] Carnegie Forum on Education and the Economy, *A Nation Prepared: Teachers for the 21st Century*, report of the Task Force on Teaching as a Profession, Washington, DC, May 1986, p. 98.

[62] U.S. Department of Labor, Bureau of Labor Statistics, and Louis Harris and Associates Inc., cited in Carnegie Forum, op. cit., footnote 61, p. 97.

[63] Francis W. Horvath, "Work at Home: New Findings from the Current Population Survey," *Monthly Labor Review*, vol. 109, No. 11, November 1986, pp. 31-35.

[64] Alexander W. Austin, et. al., *The American Freshman: National Forums for Fall, 1968-1985*, Cooperative Institutional Research Institute.

[65] U.S. Department of Education, National Center for Educational Statistics, *The Condition of Education*, 1982 Edition (Washington, DC: U.S. Government Printing Office), p. 96.

[66] National Education Association, "Status of the American Public School Teacher, 1980-81," 1982; and unpublished tabulations, July 1983, in *The Condition of Education*, op. cit., 1985 edition, footnote 65.

[67] See Carnegie Forum, op. cit., footnote 61.

[68] Betty M. Vetter, "Supply and Demand for Science and Math Teachers," National Institute of Education, Conference on Teacher Shortage in Science and Mathematics, Washington, DC, Feb. 8-10, 1983.

[69] U.S. Congress, Office of Technology Assessment, "Education," sector study, Washington, DC, 1987.

[70] Carnegie Forum, op. cit., footnote 61.

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[71] Ibid., p. 31.

PERSONAL BUSINESS AND COMMUNICATION

Recent Trends

The skills required to provide the amenity of Personal Business and Communication are dominated by managers and clerical personnel (see figure 12-9). Information technology is likely to have a particularly dramatic impact on jobs in this sector.

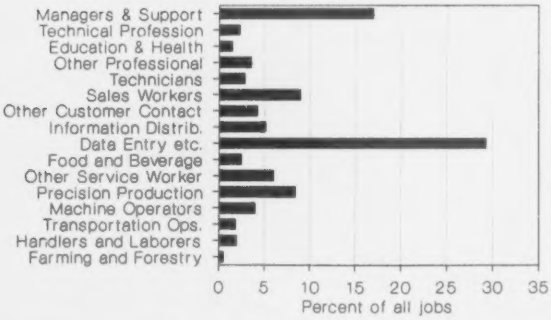
Of the industries that contribute the most jobs in this sector, only the heavily capitalized communications industry has achieved productivity growth rivaling that of manufacturing; productivity in this sector has been spectacular, rising 750 percent between 1954 and 1984.[72] Productivity gains were far lower in banking (where reported productivity actually fell during the 1970s), insurance, law, and real estate.

New technology has the potential to change the mix of skills in the transactional businesses that are the principal deliverers of Personal Business and Communication, but the changes have been extremely difficult to measure. In fact, technical changes may reverse recent trends slowing productivity growth in communications, where complex and highly differentiated services requiring more personalized attention may lead to lower measured productivity while they result in higher productivity growth rates among office-based operations.

The discussion of chapter 11 showed how the choices management must make about the use of technologies translate into stark differences in the number and quality of jobs in transactional businesses. Because of the sharply contrasting possibilities, and the near impossibility of using objective measures such as reported job descriptions to understand trends, analysts are constantly forced to fall back on anecdotes. Unfortunately, there are two opposing classes of anecdotes, with radically different pictures of the direction of office employment; both descriptions are true.[73]

Possible employment scenarios include a situation in which most skill has been built into equipment—in this case, computer and communications equip-

Figure 12-9.-Jobs Needed To Produce Personal Business and Communication in 1984 (percent of 5.8 million jobs)



SOURCE: See table 10-6 of chapter 10.

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[72] U.S. Department of Labor, Bureau of Labor Statistics, "Productivity Measures for Selected Industries," Washington, DC, various years.

[73] See, for example, L. Cummings, *The Rationalization and Automation of Clerical Work*, Master's Thesis, Brooklyn College, 1977; Maarten DeKadt, "Insurance: A Clerical Work Factory," in Andrew Zimbalist, ed., *Case Studies in the Labor Process* (New York: Monthly Review Press, 1979); E. N. Glenn and R. Feldberg, "Degraded and Deskilled: The Proletarianization of Clerical Work," *Social Problems*, vol. 25, October 1977; E.N. Glenn and R. Feldberg, "Technology and Work Degradation: Effects of Office Automation on Women Clerical Workers," in Joan Rothschild, ed., *Machina Ex Dea* (Elmsford, NY: Pergamon Press, 1983); Joan M. Greenbaum, *In the Name of Efficiency* (Philadelphia: Temple University Press, 1979); Ida Hoos, *Automation in the Office* (Washington, DC: Public Affairs Press, 1961); K. Nussbaum and J. Gregory, "Race Against Time: Automation of the Office" (Cleveland: Working Women Education Fund, April 1980); and U.S. Congress, Office of Technology Assessment, *Automation of America's Offices*, OTA-CIT-287 (Washington, DC: U.S. Government Printing Office, December 1985); H. Hartman, R.E. Kraut, and L.A. Tilly, eds., *Computer Chips and Paper Clips* (Washington, DC: National Academy Press, 1986); K.S. Koziara, M.H. Moskow, and L.D. Tanner, eds., *Working Women* (Washington, DC: The Bureau of National Affairs, Inc., 1987).

ment instead of advanced production machinery—leaving operators to perform highly routine but stressful occupations. Telephone information operators, assisted and monitored by computer equipment, are an extreme example. At the other extreme, highly differentiated products in commercial insurance or financial services can require close cooperation of teams composed of managers and paraprofessionals.

Available data provide a poor guide to much of what is happening in this sector. Productivity gains among transactional businesses require major changes in management and organization. These changes affect not only clerical employees, but managers, professionals, and technical support staffs as well. In many cases, the distinctions between clerical and managerial jobs have become almost impossibly blurred. One-third of all the job growth in finance, insurance, and real estate businesses between 1983 and 1986 resulted from new positions for executives, administrators, and managers, even though these occupations represented only 22 percent of all jobs in these businesses in 1983 (see table 12-3). Administrative support jobs, on the other hand, were responsible for only about 30 percent of job growth, even though these clerical positions represented 43 percent of the 1983 work force.

The distribution of work within the clerical work force is also changing. Table 12-4 provides a bewildering picture. Why did the number of supervisors grow rapidly and then fall? Why did the number of mail delivery jobs increase nearly as rapidly as jobs for computer operators? Exactly what are these "computer operators" doing? A careful examination of an important industry in this sector can provide some clues but no completely satisfactory answers.

Table 12-3.—Changes in the Occupation Mix of Finance, Insurance, and Real Estate, 1983-1986

Occupation	Share of 1983-86 job gain	Share of 1983 jobs
Executive, administrative, and managerial	33.2	22.3
Professional specialty	0.9	2.4
Technicians and related support	0.6	1.8
Sales	28.5	23.2
Administrative support (including clerical)	31.3	42.8
Service occupations	3.6	4.3
Precision production, craft, and repair	2.6	1.8
All other	−0.7	1.6
Total	100.0	100.0

NOTE: Numbers may not add to 100 due to rounding.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, table A-25, various issues. Data for 1986 are from November, and have not been seasonally adjusted.

The Insurance Industry: A Case Study of Automation on Employment[74]

The insurance industry provides a good example of the kinds of changes underway in many businesses providing transactional services. Automation can radically reshape the organization of work in an insurance company, changing the definition of clerical, professional, and management jobs. Clerical jobs can be upgraded and responsibilities expanded, as the tasks of data entry and analysis are combined using computers and communication networks. Professional jobs can become increasingly demanding while routine tasks are eliminated.

Table 12-4.—Growth in Administrative Support Occupations, 1983-1987

Occupation	Number (in thousands) 11/83	11/87	Annual percentage growth rate 11/83-11/87	11/86-11/87
All administrative support	16,628	18,539	2.76	3.4
Supervisors	667	767	3.55	−3.9
Computer equipment operators	696	901	6.67	7.5
Secretaries, stenographers, typists	4,942	5,078	0.68	4.0
Financial records processing	2,470	2,403	−0.69	−0.7
Mail and message distributing	832	991	4.47	7.4
Other administrative support	7,021	8,399	4.58	4.2

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, Table A-22, various issues.

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[74] This material draws heavily on Barbara Baran, "Technological Innovation and Regulation: The Transformation of the Labor Process in the Insurance Industry," contract report for the Office of Technology Assessment, Washington, DC, January 1985.

Individuals are now given a variety of different titles (such as "paraprofessional," "skilled clerical," "paratechnical," or "professional clerical"), and often use computer terminals to process highly standardized information on applications and payments. These new positions combine tasks once done by data entry clerks, raters, and underwriters. In effect, skilled clericals, "(*limited by the decision parameters built into the machines*) are responsible for the soundness and accuracy of the millions of routine risks their companies write."[75] This pattern of work organization already dominates directly marketed insurance products, where customer service representatives are essentially sales people, underwriters, raters, data entry clerks, and claims personnel.

There is considerable potential for productivity increases. Between 1970 and 1980, for example, the number of life insurance policies written increased 49 percent, while the labor force expanded by 10 percent. Property/casualty insurance, not as heavily automated, did not show equivalent gains. Nevertheless, some firms indicated that they enjoyed a 70 to 85 percent increase in output per operator when cathode ray tubes (CRTs) replaced older data processing equipment. Turnaround time was cut dramatically, while storage space was reduced by 50 percent or more.[76] Quality was also improved.

This system can either result in widening the division separating clerical from professional work or make the division smaller to the point where there is no clear distinction between a skilled clerical and middle manager. The difference depends on the extent to which the market demands relatively routine, standardized products that lend themselves to high levels of automation, and on the management strategies of the companies involved. One estimate indicates that approximately 70 percent of the policies in life insurance, and 50 percent in the property/casualty area, are extremely routine and can be automated.[77]

Changes in occupation patterns illustrate the net effect of the developments just described most clearly. Between 1978 and 1981, when overall insurance employment grew by 8 percent, professional and technical jobs grew nearly 40 percent faster than the average, and managers and officers grew nearly 60 percent faster (see table 12-5). Total clerical employment grew far more slowly than average job growth, as did growth of specialized sales workers. Computer-based positions increased (computer programmers increased by 41 percent), while jobs in traditional areas such as bookkeeping were lost—presumably, these titles were redefined, or jobs were replaced by systems analysts. There was virtually no growth of specialized underwriters, since their tasks were increasingly handled by skilled clericals; significant growth was seen among clerical life/health claims examiners, clerical office machine operators, secretaries, and clerical supervisors. Other clerical categories registered little change, although file clerks seem to be on the decline due to the ability of automation to assume such tasks.

Table 12-5.—Percent Change in Selected Occupations in the Insurance Industry, 1978-1981

Occupation	Change
Professional/technical	11.4%
Accountant/auditor	11.4
Systems analyst, EDP	44.4
Claims examiner, property/casualty	10.1
Special agent	86.3
Underwriter	0.8
Computer programmer	41.1
Managers/officers	13.4
Sales workers	7.0
Clerical	6.6
Accounting clerks	4.7
Hand bookkeeping	−1.1
Claims clerk	3.1
Claims adjuster	2.2
Claims examiner, life/health	26.2
Clerical supervisor	9.4
File clerk	−9.6
General office clerk	−0.3
Office machine operator	17.9
Rater	3.2
Secretary	12.9
Typist	−0.1
Total	8.3

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, *Occupational Employment Survey*, Washington, DC, 1978 and 1981.

Changes in job classifications must be treated with some caution. The survey conducted for this analysis discovered cases where managers were locked into compensation schemes that did not adequately adjust for inflation. As a result, the only way to increase a person's pay was to increase his or her rank. In other cases, jobs were redefined and reclassified in response to successful affirmative action suits. Indeed:

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[75] Ibid.

[76] LOMA, *Word Processing Survey*, 1979.

[77] The U.S. Bureau of Labor Statistics classifies property/casualty claims examiners as "professional and technical" jobs, while life/health claims examiners are classified as "clericals."

> Not only were women moved into managerial positions to meet company quotas, but men were at the same time often also promoted from professional to managerial categories to maintain their seniority. The company where we conducted our case study, for example, had been hit by a successful affirmative action suit. Between 1973 and 1979, supervisory personnel in their underwriting departments grew by 202 percent.[78]

Automation of Insurance: The Mass Production Approach

The new skilled clerical jobs, while routine, are more demanding than the ones they replaced. It is not obvious, however, that they offer better job opportunities. To begin with, these new positions pay little more, and in some cases no more, than clerical jobs. Yet the new jobs carry considerably greater responsibility, only without much sense of control—a situation that can increase stress. In the older pattern of clerical work, employees were often able to do routine tasks nearly automatically and could enjoy the sociability of an office environment; the new systems require far greater concentration and fewer opportunities for casual conversation.[79] The new work involves a "curious combination of abstraction and routinization" and, since there is little tangible evidence of work completed, a reduced sense of accomplishment[80] (see p. 371).

While these changes have had a significant impact on the productivity of clerical workers, their effect on middle management positions may be even greater. Standardization and computerization eliminate a number of tasks once reserved for professional underwriters and claims examiners. Those that remain often have significantly changed jobs. In the newer systems, much less of a professional's time is spent reviewing routine matters that can or have been automated; more time is spent "living by one's wits." Underwriters devote more time wrestling with exceptions and difficulties, developing new products, selling products to customers, or—in the case of property/casualty insurance—working in the field.

This pattern of organization has affected not only the insurance companies themselves but staffing in insurance agencies. Automation forces agencies to increase emphasis on sales, since much of their service functions have been moved to other parts of the insurance system. This is significant because between 1970 and 1981, agencies and brokerage houses generated 45 to 50 percent of all new insurance jobs and 61 percent of all new clerical jobs. The agencies, particularly the captive agents of a large insurance firm, are becoming more closely integrated with the parent company.

Productivity improvements in agencies resulted from a vast decrease in routine paper work and record keeping. Routine policy renewal or endorsement is the most time-consuming operation for personal lines, and the second most time-consuming process for commercial insurance lines. Nearly 40 percent of the document handling for these operations involves rehandling or correcting of previously handled documents. A survey of agency productivity increases occurring within 2 years of automation showed that revenues per employee increased by an average of 70 percent, with agency gains ranging between 50 and 125 percent.[81]

Automation of standardized products can also affect the location of work and the sexual composition of the work force. The new processing centers are typically located in suburban facilities, which are physically separated from the corporate headquarters of the company (see ch. 5.) One industry survey found that 75 percent of industry firms had made major changes in the location of their facilities in the past 5 years; 94 percent of these, or 71 percent of all firms, had shifted the bulk of their work to suburban locations. Of the remaining 29 percent, most had either made small-scale transfers of work to suburbs or small towns or were actively considering such moves.[82]

Personnel managers often search for regions with large numbers of white housewives with high school educations. It was felt that such people are less likely to demand high wages, more likely to accept part-time work, and more willing to be flexible in adjusting to newly automated systems.[83]

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[78] Baran, op. cit., footnote 74, p. 106.

[79] P. Adler, "Rethinking the Skill Requirements of the New Technologies," Harvard Business School, working paper, Cambridge, MA, October 1983.

[80] S. Zuboff, "Some Implications of Information Systems Power for the Role of the Middle Manager," Harvard Business School, working paper, May 1983.

[81] Temple, Barker, and Sloane survey, in *National Underwriter*, May 13, 1983, pp. 18-22.

[82] B. Baran, op. cit., footnote 74.

Approximately 88 percent of all new jobs added in insurance between 1960 and 1982 were filled by women.[84] Most of these jobs were clerical—92 percent of clerical employees and two-thirds of technical employees in insurance are female—but women moved increasingly into management positions during the 1970s. The proportion of females in management positions grew from 11 to 24 percent between 1970 and 1979; women professionals grew from 17 to 38 percent, and women technicians from 38 to 65 percent.[85]

Part of this increase resulted directly from successful affirmative action suits in the 1970s, but some evidence suggests that automation is associated with a shift to a heavily female work force. The records of one large property/casualty insurer indicated that women comprised 70 percent of the work force of the highly automated personal lines of insurance, but only 56 percent of the less automated commercial lines. Similarly, women held 82 percent of the grade 7 underwriter jobs in personal lines but less than 60 percent of the jobs in commercial lines.

Even the physical environment of the newer administrative settings reflects the changes in occupations brought by automation. The walls of many private offices have been torn down, and middle managers and professionals now work side by side with clericals in shoulder-high cubicles.[86]

Automation of Insurance: The Team Approach

While automation can produce relatively routine and unpleasant jobs for skilled clericals, it can also create situations where routine clerical work is absorbed into jobs that are interesting, varied, and rewarding. This is particularly true in such areas as commercial insurance, where products are complex and difficult to standardize. It may also be true in areas where overall volume is comparatively low, but local customer services are desirable. Such local offices are staffed by multi-disciplinary teams working closely together, in which skilled clericals work directly with agents—something once the exclusive province of underwriters—and are given considerable amounts of responsibility.

Over 70 percent of the life insurance companies interviewed said that they had introduced some type of team arrangement, emphasizing geographic areas where work volume is comparatively low.[87] They are tied to extremely sophisticated computers and data retrieval systems through telecommunications networks (such as IVANS, or insurance value-added networks). Between 1973 and 1983, the ratio of claims handled by an office staff to claims handled by field offices increased from 0.5 to 3.5.

Carriers and agencies that can expand their operations to provide a variety of financial services require a new mix of talents and a flexible work staff. Increased use of training programs and new licenses in this area indicate that agency employees are expanding their scope.

Looking to the Future

The complex changes in the organization of production in the insurance industry have led to a number of conflicting theses about the future of employment in all industries associated with providing Personal Business and Communication. Clearly, there is significant room for network-wide productivity growth, since many transactional businesses can benefit from the introduction of existing technology and the power of integrated information and communications systems is growing (see discussion in ch. 6).

A detailed survey of industry specialists conducted by Georgia Institute of Technology suggested that, given optimistic assumptions about the capacity and utilization of new information technology, output per clerical worker could grow at an annual average rate of 7 percent during the next two decades, with the bulk of the increase coming between 1990 and 2000.[88] The labor reduction coefficients calculated by the same survey (the ratio of the hours needed to complete a task in the year 1980 to the number of hours needed to complete the same task in the year 2000) averaged 0.42, with the productivity gains being greatest for data processing and database management, and least for communications and monitoring. Similar projections for 1990 and 2000 appear in table 12-6, first for the insurance industry and then for selected industries within the Transactional Activities sector.

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[83] Ibid.

[84] U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, various issues.

[85] Eileen Applebaum, "Alternative Work Schedules of Women," paper presented to the Economics Department of Temple University, Philadelphia, PA, July 1985.

[86] Based on interviews reported in Baran, op. cit., footnote 74.

[87] Ibid.

[88] D.J. Roessner et al., *Impact of Office Automation on Office Workers*, Georgia Institute of Technology, April 1984.

If clerical work can be automated to the extent suggested by the Georgia study, the distribution of jobs in the insurance industry would no longer be a pyramid, with a small number of top managers, a larger number of professionals and technicians, and a still larger number of clerks. Rather, it would be shaped more like a diamond, with a small number of top managers and clerks and a large number of quasi-professionals in the middle.

Table 12-6.—Labor Coefficients for the Insurance Industry

	1990		2000	
Occupation	S2	S3	S2	S3
Managers	0.99	0.84	0.88	0.50
Sales workers	0.98	0.94	0.96	0.89
Clerical	0.84	0.64	0.70	0.53

NOTE: S2 and S3 refer to different scenarios used in the study. The coefficient for clerical workers is a weighted average.

SOURCE: Wassily Leontief and Faye Duchin, *The Impacts of Automation on Employment, 1963-2000*, Institute for Economic Analysis, April 1984.

Labor Coefficients for 1990 in Selected Transactional Industries

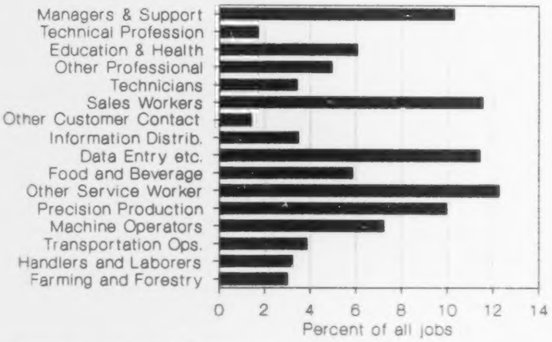
Occupations	Banks	Credit agencies	Securities	Insurance	Business services	Miscellaneous services
Professional/technical	1.27	0.96	0.85	0.86	1.11	1.02
Manager	1.13	0.87	0.90	0.84	1.08	1.11
Sales	1.05	0.76	0.68	0.95	0.93	0.96
Clerical	1.10	0.83	0.72	0.71	1.01	0.95

SOURCE: M.P. Drennan, "Implications of Computer and Communications Technology for Less Skilled Service Employment Opportunities," report for the U.S. Department of Labor, USDL-21-36-80-31, 1984.

RECREATION AND LEISURE

The rapidly growing demand for the Recreation and Leisure amenity has made this an increasingly important source of employment in the American economy. According to the U.S. Travel Data Center's definition of the travel industry, the industry employed some 4.5 million people in 1972 (a little over 6 percent of the work force).[89] Using the somewhat different definition of the industry employed in this analysis, by 1984, it was directly and indirectly employing 8.5 million people, or 8 percent of American jobs. Providing this amenity creates significant numbers of jobs for virtually every occupation category (see figure 12-10). While comparatively few technical jobs are created, recreational spending ripples into both service and production occupations.

Figure 12-10.-Jobs Needed To Produce Recreation & Leisure in 1984 (percent of 8.5 million jobs)



SOURCE: See table 10-6 of chapter 10.

Will employment in the Recreation and Leisure network continue to expand at the same rate? The evidence is mixed. The service and retail jobs that make up the vast majority of the sector's work force are not easily replaced by labor-saving technology. This implies that recreation employment will continue to be labor-intensive. In fact, a recent analysis of the lodging industry suggests that hotel industry is becoming even more labor-intensive: in 1933, there was one employee for every 5 hotel rooms; in 1982, there was one for every two rooms.[90]

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[89] Albert J. Gomes, *Hospitality in Transition: A Retrospective and Prospective Look at the U.S. Lodging Industry*, American Hotel and Motel Association, 1985, based on data from the U.S. Department of Labor, Bureau of Labor Statistics, "Supplement to Employment and Earnings, United States 1909-1978," Washington, DC, July 1984.

On the other hand, if there is a slowdown in the rate of growth of recreation demand, then demand for labor may drop as well. Coupled with downward pressure on work force levels because of decreasing numbers of young people who have traditionally worked in leisure industries, this could limit job creation in the sector.

While the sector has clearly generated a significant amount of employment, many of the jobs created by restaurants, hotels, and amusements do not offer high wages or significant opportunities for advancement. In 1987, these industries respectively paid roughly half, two-thirds, and three-quarters of the average hourly wage.[91]

But these figures focus on only the direct services provided by the away-from-home recreational businesses, neglecting the significant number of jobs resulting from the production of products for recreation and leisure. Outdoor recreation means purchases of everything from tennis rackets and hiking shoes to recreation vehicles. The businesses themselves purchase manufactured products ranging from french-fry slicers to jet aircraft. Travel generates employment for travel agencies and the people who make and maintain the complex communication and data processing systems on which that these businesses now depend. New hotel and motel construction was responsible for 11 percent of all new 1986 nonresidential construction.[92]

Figure 12-10 indicates that 10 percent of the jobs associated with this amenity fall into the relatively good paying managerial and precision production occupations. When indirect effects are included, the Recreation and Leisure amenity generates more jobs for precision production manufacturing jobs than it does food and beverage workers.

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[90] Albert J. Gomes, op. cit., footnote 89.

[91] U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings*, vol. 34, No. 12, December 1987, table C2, pp. 83-97. Wages are for September 1987, reflect money payments only, and do not include tips.

[92] Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 5.4.

GOVERNMENT

Federal defense and government activities like fire, police, and administration activities that could not be allocated to other amenity groups produce about 13.1 million jobs. Managers, education and health professionals, and data entry workers represent over 40 percent of all of these jobs (see figure 12-11).

A large share of the government workers not easily traceable to an amenity network like Education or Health work at the Federal level. The Department of Defense, the Postal Service, and the Veterans Administration employ over two-thirds of all Federal workers, and have been responsible for nearly all growth in the Federal work force since 1977.[93] Federal employment has grown at only one-third the rate of private employment since 1977, resulting in a decreasing share of the overall labor force[94] (see figure 12-12). Outside the Department of Defense, Federal employment growth was slowed by the hiring freeze imposed in 1981, reduced employment ceilings for many agencies, and cutbacks of approximately 14 percent and 17 percent at two large Federal agencies: the Department of Health and Human Services and the Department of Agriculture.[95] By 1986, the Federal work force was less than half that of State and local governments.

In part because of the growing complexity of government administration, and in part because some clerical activities are handled under contract, the Federal work force is increasingly composed of skilled professional and administrative jobs. Jobs in these categories were 35 percent of all Federal jobs in 1976 and 42 percent in 1986.[96] The educational attain-

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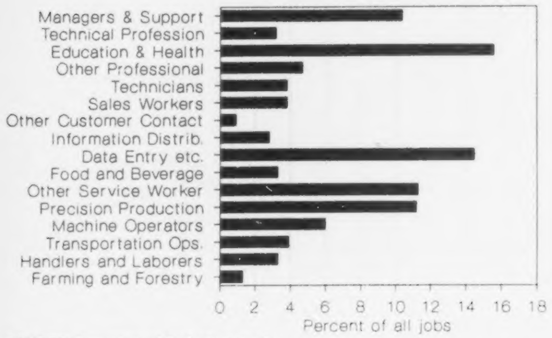
[93] U.S. Congress, Congressional Budget Office, *Federal Civilian Employment* (Washington, DC: U.S. Government Printing Office, December 1987), p. x.

[94] Ibid., p. ix.

[95] Ibid., p. xii.

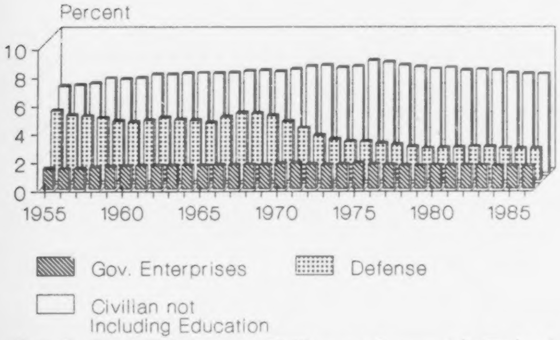
[96] Ibid., p. xiii. Statistics refer to non-postal employees.

Figure 12-11.-Jobs Needed for Defense and Other Government in 1984 (percent of 13.1 million jobs)



SOURCE: See table 10-6 of chapter 10.

Figure 12-12.-Government Employees Not Directly Involved in Education (as a percent of all employed persons)



How To Read This Figure: Civilian employment in Federal, State, and local government (not including State education employees) peaked in the mid 1970s and has subsequently declined as a fraction of all employed persons. Federal defense employment (a category that includes the Coast Guard) fell sharply at the end of Viet Nam War. Federal, State and Local Enterprises (e.g., power authorities) have accounted for a nearly constant share of employed persons since 1955. Employed persons include full-time employees, self-employed persons, and part-time employees and converted to full-time equivalents.

Notice that the employment in this figure are NOT the same as that shown in figure 12-11. Figure 12-11 shows both direct and indirect employment and excludes government employees who can be traced directly to an amenity network like Food.

SOURCE: U.S. Department of Commerce, Bureau of Economic Analysis, "National Income and Product Accounts," historical diskettes, table 6.10.

ment of Federal workers have also increased—31 percent of all non-postal employees held a bachelor's degree or better in 1986, up from 25 percent in 1976. The 1986 national average was 22 percent.[97]

Although the Federal government is often depicted as inefficient and overstaffed (it apparently takes 55 employees to answer a letter received by the Secretary of Health and Human Services[98]), the productivity of the Federal government has increased at an annual rate of 1.6 percent from 1979 to 1986—significantly higher than other service sector industries such as finance, insurance, and real estate (−.8 percent); legal services (−1.9 percent); and business services (−1.8 percent).[99]

Measured productivity in government has slowed since 1982. The decline can be attributed in part to a negative measured rate of productivity growth in the Department of Defense.[100] Productivity in the non-postal, civilian portion of the Federal government grew at an annual rate of 2.2 percent between 1982 and 1986, rivaling some of the productivity increases occurring in the manufacturing sector.

The source of productivity gains in non-defense areas can be tied to the widespread implementation of computers into the workplace, suggesting that significant future employment growth in this sector is unlikely. Introduction of computers in the Social Security Administration, for example, resulted in a reduction of employment.[101] When the Department of Commerce implemented a new electronic system for issuing export licenses, the approval time for overseas sales was cut from from 13 days to 3.[102] The Internal Revenue Service is experimenting with a new electronic tax filing system that promises to cut processing time by a factor of two, reduce filing errors by a factor of ten, and deposit a refund check in the taxpayer's bank account three weeks after the return is filed.[103] This new system should not only hold down labor costs in the IRS, but should also have a large indirect effect on the Postal Service as the more than one billion pieces of yearly tax correspondence are reduced.

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[97] Ibid., p. xiii; and U.S. Department of Labor, Bureau of Labor Statistics, "Table 13: Occupation of employed persons by age and years of school completed," unpublished.

[98] "The Grace Commission Report," 1983, cited in Lewis Lapham, Michael Pollan, and Eric Etheridge, *The Harper's Index Book* (New York, NY: Henry Holt and Co., 1987), p. 43.

[99] U.S. Department of Labor, Bureau of Labor Statistics, "Time Series Data for Input-Output Industries," June 1987, unpublished.

[100] Ibid., p. 22.

[101] Ibid., p. 20.

[102] Lee Mercer, Acting Deputy Undersecretary for Export Administration, U.S. Department of Commerce, "'Elain' Joins 'Stela' to Cut Processing Time," *Business America*, vol. 109, No. 5, Feb. 29, 1988, pp. 7-10.

This document was typed by professional staff using the same desktop personal computers that were used to perform all of the OTA calculations presented here and to create all of the graphics. The hardware and software costs averaged about $2,500 per station. In most cases, the data used in the analysis was received from Federal agencies over the telephone line or on floppy disks that could be inserted directly into the desktop equipment. The staff that once performed largely clerical work have become specialists in perfecting graphics or formatting digital text files.

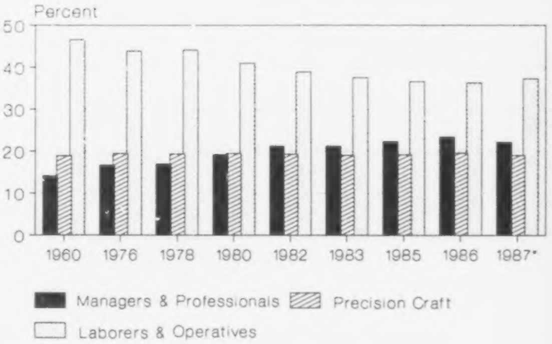
MANUFACTURING

Manufacturing employment is the paradigm of work in U.S. society. The vocabulary of labor analysis and statistics, and much of the scholarly debate over changes in work force skills, is built around production work.

These paradigms change slowly even though classic manufacturing jobs—craftsmen, laborers, and machine operators—are likely to be only 10 to 15 percent of the labor force by the end of the century. Even in manufacturing the mix of skills needed may increasingly resemble the mix of skills needed by businesses like banking and insurance.

The productivity gains achieved with new manufacturing technology have not uniformly reduced the need for all kinds of occupations. For the most part, they have resulted in sharp declines among manual workers (operators and laborers) rather than among management staff (see figure 12-13). Workers classified as "precision production, craft, and repair" have held a roughly constant share of jobs.

Figure 12-13.-Occupations in Manufacturing (as a percent of all manufacturing jobs)



*November 1987.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, matrices for Employment by Occupation and Industry, Washington, DC, various years.

As in the case of insurance (discussed in the previous section), there is considerable uncertainty over the way new manufacturing technology can or should be used. Fragmentation of markets, and the inherent characteristics of robotic and other production equipment, seem to point away from mass production runs and toward the production of smaller batches (see ch. 5). Using the technology installed in most major metal shaping facilities today, producing batches of 10 or less requires ten times as many people per piece produced as a production line making 1,000 or more identical parts.[104] Advanced "flexible manufacturing systems" (FMS) can result in a radical change in the economics of mass as opposed to batch production. The Japanese, who are being forced away from mass production by the need to serve smaller local markets as well as export markets, are making heavy use of FMS to increase the productivity of small batch production dramatically.[105] A flexible manufacturing system (FMS) used in small batch production runs may require only one-fifth the number of employees needed with conventional systems (see table 12-7).

Even more importantly, the FMS systems change the nature of jobs created in manufacturing. For example, FMS creates nearly twice as many engineering jobs per part produced as a conventional sys-

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[103] Judy Rosenfeld, "The Electronic Taxman," *PC World*, April 1987, pp. 184-191.

[104] Hiroyuki Yoshikawa, K. Rathmill, and J. Hatuany, *Computer-Aided Manufacturing: An International Comparison* (Washington, DC: National Academy Press, 1981).

[105] Ramchandran Jaikumar, "Postindustrial Manufacturing," *Harvard Business Review*, vol. 64, No. 6, November/December 1986, pp. 69-76.

Table 12-7.—Manpower Requirements for Metal-Cutting Operations: Flexible v. Conventional Manufacturing
(workers need to produce the same number of identical parts)

Type of activity	Number of workers Conventional U.S. system	 Japanese FMS
Engineering	34	16
Manufacturing overhead	64	5
Fabrication	52	6
Assembly	44	16
Total	194	43

NOTE: There is no column for a U.S. FMS because as of the end of 1986, no U.S. machine tool producer had an FMS on line.

SOURCE: Ramchandran Jaikumar, "Postindustrial Manufacturing," *Harvard Business Review*, November/December 1986, p. 73.

Flexible Manufacturing Systems (FMS) Used for Machining Metal Collars

	Before FMS	After FMS
Number of machine tools	8	4
Number of processes	3	1
Number of workers	10	2
Machine utilization	50%	75%
Factory availability per day	16 hours	24 hours
Necessary lead time	6 days	1 day

SOURCE: Okuma Machinery Works Ltd., reported in B. Stokes, "The 21st-Century Factory," *National Journal*, Feb. 13, 1988, p. 383.

tem (again see table 12-7). Successful use of FMS to achieve high degrees of flexibility in rapidly moving markets requires close cooperation between design engineering and production. Products and production techniques must be designed simultaneously. The Japanese find, for example, that the productivity of software development (usually considered a "service" occupation) is critical in the overall cost of products made from FMS; for example, Yukio Hasegawa, an expert on robotics at Waseda University, estimates that the cost of FMS production could be cut by 25 percent given advances in the productivity of software development.[106] Teamwork, a mixture of skills, and a high degree of intellectual flexibility appear necessary to make FMS work.

The discussion in chapter 6 explained that the jobs created by new manufacturing strategies depend heavily on management choice. There is some evidence that the Japanese have moved more rapidly to exploit the flexibility inherent in FMS while U.S. firms have opted to use the equipment more as a direct substitute for mass production. A recent survey found that U.S. manufacturers used FMS systems to make an average of 10 different parts while the Japanese averaged 93 parts per FMS system.[107]

Production Workers

The debate over whether new production equipment will lead to a net increase or decline in the skills of manufacturing workers is impossible to resolve given the uncertain future of new production technology. Chapter 11 summarized some of the debate. It is clearly possible that new production equipment would lower skills on the shop floor but create many highly skilled support jobs, both in manufacturing enterprises and in the businesses that supply them.

Even the comparatively narrow question of whether new manufacturing technology will make production work more interesting and challenging or more mundane proves difficult to resolve. While there are no convincing data on the subject, anecdotes suggest that management has a wide range of choice in the kinds of jobs that are created in new production systems.[108] Since experience is limited, it is difficult to prove which choice is preferred. There are reasons to believe that attempts to achieve productivity without actively involving workers in the design and operation of a plant can prove disastrous—particularly in dynamic situations where products change rapidly.[109]

Obviously not all managers are convinced of the advantages of designing systems around a skilled production force. Computer-controlled equipment has been introduced in a way that, as one manager put it the "... operator can be just short of an idiot"[110] (see box 12-A). In fact, a majority of the operators interviewed in one survey believed that the use of numerically controlled machine tools made their jobs less interesting and less rewarding. As one operative put it, "you get to be, in my opinion on a NC [numerically controlled machine tool], a little

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[106] Bruce Stokes, "The 21st-Century Factory," *National Journal*, Feb. 13, 1988, vol. 20, No. 7, p. 386.

[107] Ibid.

[108] Carol Parsons et al., "The Development of Programmable Automation Systems in Discreet Parts Manufacturing Industries," contract report prepared for the Office of Technology Assessment, Washington, DC, 1984.

[109] Ray Marshall, "Economic Performance and Work Force Quality," Testimony before the Joint Economic Committee, U.S. Congress, Oct. 21, 1987.

[110] Parsons, op. cit., footnote 108.

Box 12-A.—Does Technology De-Skill Production Workers?

"In most companies the programmer is paid as a grade 9 while the operator is paid as a grade 6. But in our company there aren't any up-in-the-front-office type programmers. So the CNC operators are paid as a grade 8. This was OK with the operators but some of the other employees were angry because operators spend a lot of time just sitting reading a book."

—A vice president for manufacturing of a firm in Iowa

"Yes and no. Operators now have new skills. With the old machines they had to have a feeling for tool nudging and continuous adjustments. Now they need to understand the cycle of a program. We also need more competent electronic technicians and troubleshooters. There are poor diagnostics on the [CNC] machines."

—A vice president for manufacturing in an independent producer of manifold and other engine parts that has used CNC for 3 years.

SOURCE: Carol Parsons et al., "The Development of Programmable Automation Systems in Discreet Parts Manufacturing Industries," contract report prepared for the Office of Technology Assessment, Washington, DC, 1984.

weak-minded."[111] In such cases, a job once held by a trained machinist is replaced by one in which an individual performs simple loading operations and spends more time waiting for something to go wrong. Programming of the equipment is removed from the shop floor, and placed in the hands of specialists. When something does go wrong, the worker on the floor can do little more than call a repair team. The result is generally boredom, as well as frustration over loss of autonomy; moreover, responsibility without control can create enormous stress. The feeling of helplessness can be increased when workers loose incentive bonuses because of equipment failures over which they have no control.

On the other hand, there are examples of shops where teams of designers and operators have collaborated in a way that benefits the entire work force. An examination of textile machinery manufacturing in West Germany found that "firms concentrate their expertise in coordinating the design and assembling the full product."[112] Operators in such facilities may take delight in reprogramming equipment to reduce the processing time by a few seconds and beat the record of the previous shift. In one Japanese firm employing an FMS, for example, "systems engineers with a thorough knowledge of several disciplines . . . [rotate] through all manufacturing departments,"[113] so that each would be able to gain the kind of competitive expertise that may be unobtainable without a coordinated approach to design and assembly.

The Japanese seem to have faith that new production technology will lead to much higher demands on the skills of their workers. An increasing fraction of their production jobs are held by college graduates, or by high-school graduates whose knowledge of mathematics and science rivals that of college juniors or sophomores in the United States. Nissan Motors recruits high school graduates with a rigorous nationwide test that places particular emphasis on mathematics and science.[114]

Equipment Maintenance

One undisputed trend is the increasing need for highly skilled individuals capable of designing, installing, and maintaining new automated equipment. An overwhelming majority of firms interviewed indicated that they had difficulty finding qualified personnel; most had instituted in-house training programs. These training programs are not trivial. The equipment involved is highly complex and cannot be understood with a few brief lessons. A survey of 48 British engineering plants in 1981 indicated that firms with numerically controlled tools thought they needed maintenance personnel with higher skills, while those that had not automated indicated that they hoped to simplify equipment so that the skills of maintenance personnel could be reduced.[115]

Several of the automated firms indicated that they were concerned about raiding by other firms of trained personnel, and were nervous about their training investments. Many of the advanced systems require people familiar with a number of fields: hydraulics, electronics, and mechanical equipment.[116] These jobs plainly demand a flexible intellect and can be quite challenging. They can also be extremely stressful, since a single problem in a highly connected factory system can shut down a large and expensive facility. Such problems are often difficult to diagnose under pressure.

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[111] Ibid., p. 201.

[112] Charles Sabel et al., "How To Keep Mature Industries Innovative," *Technology Review*, vol. 90, No. 3, April 1987, p. 30.

[113] Jaikumar, op. cit., footnote 105, p. 75.

[114] B. Stokes, op. cit., footnote 106.

[115] P.J. Senker and T. M. Brady, "Skills for Automation: The Maintenance Training Gap," paper prepared for the 2nd International Conference on Human Factors in Manufacturing, West Germany, June 11-13, 1985.

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[116] Parsons, op. cit., footnote 108.

Chapter 13

Alternative Paths for the U.S. Economy

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Chapter 13

Alternative Paths for the U.S. Economy

Given the enormous range of choices Americans face about what to buy, what to produce, how to produce it, and whom to employ, confident forecasts about the future are absurd. To an extent never before possible, the future hinges on conscious choice. It is possible, however, to construct self-consistent descriptions of the future that may provide a useful guide for policy makers.

This chapter examines the impact on the economy of a number of different scenarios, which include different assumptions about change in five main areas:

- consumer and government purchases,
- international trade,
- production recipes,
- labor productivity, and
- staffing patterns.

Chapters 2 through 12 provide quantitative and qualitative support for likely changes in these broad areas. The effects of these assumptions are summarized by two indicators of change: shifts in the sectoral composition of the Gross National Product (GNP) (as discussed in ch. 5) and changes in the numbers of jobs in each production sector and occupation (as discussed in ch. 10).

Four scenarios are constructed from the various assumptions made about each of the broad areas:

1. "Trend" is an attempt to extend trends established during the past two decades into the future.
2. "Manufacturing" attempts to maintain the traditional lines of manufacturing.
3. "Stagnation" assumes that growth slows due to slack demand, reduced productivity, and a trade situation in which the United States slips behind its trading partners in the production of sophisticated equipment and services.
4. "Transformation" reflects a series of hypotheses about the ways consumers may elect to purchase amenity and the manner in which producers may choose to organize production. The underlying theme is one of high flexibility in the tailoring of goods and services to targeted tastes and markets. This scenario assumes that trade falls sharply as a fraction of economic activity because most products can be made more efficiently in locations close to the consumer, due to both reduced material and energy inputs and the fast pace of technology transfer.

Two of these scenarios, the Trend and Transformation scenarios, outlined in earlier chapters, include both a low- and a high-growth variant, making an actual total of six scenarios. The low-growth case (in which real GNP grows at 1.5 percent per year) assumes the comparatively slow growth rates of the late 1970s and early 1980s. The high-growth case (real GNP grows at 3 percent a year) assumes that the economy is able to restore the high rates of growth of the late 1960s. These cases were chosen to illustrate the boundaries of reasonable GNP growth rates, and are in general concordance with the U.S. Department of Labor's low- and high-growth projections for the year 2000.[1]

These different scenarios will obviously result in different levels and arrangements of GNP and jobs in the year 2005. Each GNP level can, however, be produced by very different kinds of economies.

The analysis is not a closed dynamic model, in which demand for output generates a set of prices and a pattern of income which, in turn, generate purchasing patterns and a demand for output.[2] Instead, the scenarios are intended to illustrate rough parameters for the future direction of the economy, providing an awareness to possible changes rather than an exact prediction.

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[1] See Norman C. Saunders, "Economic Projections to the Year 2000," *Monthly Labor Review*, vol. 110, No. 9, September 1987, pp. 10-18.

[2] For a description of an operational dynamic model, see W. Leontief and F. Duchin, "The Impacts of Automation on Employment, 1963-2000," Institute for Economic Analysis, New York University, New York, NY, April 1984. A description of a forecasting model used by the Bureau of Labor Statistics appears in N.C. Saunders, "The U.S. Economy Through 1990—An Update," *Monthly Labor Review*, vol. 104, No. 8, August 1981, pp. 18-27; and U.S. General Accounting Office, "Bureau of Labor Statistics Employment Projections: Detailed Analysis of Selected Occupations and Industries," GAO/OCE-85-1, Washington, DC, Apr. 25, 1985.

Changes in each of the five main areas that collectively define these scenarios are called the component assumptions. These assumptions, and their individual effects on sectoral contribution to GNP and jobs, are described below, providing a sensitivity to the relative impact of each component assumption. Following this discussion, they will be combined into the six scenarios.

COMPONENT ASSUMPTIONS

The influence of assumptions about demand, trade, production recipes, productivity, and staffing patterns is examined by assuming an economy where other factors are held constant. The impact of the changes is then shown cumulatively. This means beginning with baseline patterns for demand, trade, production recipes, productivity, and staffing. First, only demand is changed and values for the other factors are left at baseline levels. Second, demand is set at a fixed future level (for instance, at the 3 percent trend level) and alternative trade patterns are explored. Third, demand and trade are set at fixed future levels and the effects of different production recipes are explored. The series is continued until all factors are considered.

This analysis is undertaken only to illustrate the direction of change resulting from altering assumptions—none of the cases can be considered realistic descriptions of the future. The calculations are based on straightforward input-output techniques described in chapters 4, 7, and 10. While most of the component estimates were prepared for 85 business sectors, uncertainties are so large that the results are displayed only for nine summary sectors to avoid giving a false sense of precision.

Consumer and Government Purchases

The analysis in Part I resulted in two types of estimates about the future of personal and government spending: a *trend* case, and an *alternative* pattern of demand built on speculation about how technology, changes in government regulation, and changes in how consumers acquire information could lead to a higher level of amenities than the trend. Estimates were made for both high- and low-growth rates (see table 2-9 of ch. 2 for a summary of the alternative demand estimates).

At the level of aggregation shown in table 13-1, these assumptions have a surprisingly modest effect on economic structure. The alternative cases result in significantly lower use of Natural Resources (primarily because of an assumed increase in the energy efficiency of houses and automobiles), higher spending on Transactional Activities, and lower consumption of High Wage Manufacturing products—all of which translates into shifting patterns of value-added for these sectors. Because productivity and staffing patterns have been kept constant, the impact on jobs mirrors the changes in value-added.

International Trade

Four trade cases were outlined at the end of chapter 8 under the assumption that the United States would achieve something approaching balanced trade in the year 2005. The cases differ in assumptions about the total volume of trade and about the comparative advantage of U.S. products. Briefly recapitulating:

1. The *Caesar* case assumes that the United States recovers a dominant position in the export of sophisticated manufactured products while trade continues to grow as a fraction of the U.S. GNP. In this case, the gross level of trade increases from the 1984 level of 22 percent to 30 percent of GNP in 2005. Exports of manufactured goods and services exceed imports while the United States becomes a slight net importer of natural resources, largely because of oil imports.
2. The *Banana* case, like the Caesar case, assumes that trade rises to become 30 percent of GNP in 2005. The Banana case, however, assumes that the U.S. trade balance is restored primarily by increasing exports of raw materials and resource-intensive manufactured products (following trends of the past decade). Exports of high technology products continue to fall. Imports and exports of services are identical to the Caesar case.
3. The *Drucker* case supposes that technological advances will lead to a decline in merchandise

Table 13-1.—Sensitivity Matrix of Jobs and Value-Added Under Different Assumptions of Final Demand

	1984		3% Trend		1.5% Trend		3% Alternative		1.5% Alternative	
Production sector	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added
Natural Resources	4.5	9.2	4.3	9.1	4.6	9.5	4.1	8.5	4.2	8.7
Construction	4.5	6.2	4.1	5.8	4.3	6.0	4.2	5.9	4.4	6.1
Low Wage Manufacturing	4.5	3.2	4.5	3.3	4.3	3.1	4.8	3.6	4.5	3.3
Medium Wage Manufacturing	9.3	9.7	8.8	9.3	9.3	9.8	8.8	9.3	8.9	9.4
High Wage Manufacturing	5.7	9.2	5.0	8.2	5.2	8.4	4.9	7.9	4.9	8.1
Transportation and Trade	26.3	19.4	25.5	19.1	25.6	19.0	26.3	19.7	25.5	19.1
Transactional Activities	12.8	24.2	12.6	24.2	12.9	24.5	13.0	24.9	12.9	24.7
Personal Services	5.6	3.6	6.4	4.2	5.8	3.8	7.0	4.6	6.4	4.2
Social Services	26.8	15.3	28.7	16.7	28.1	16.1	26.9	15.6	28.4	16.4
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total jobs in millions, GNP in trillions (1980$)	107.0	3.0	200.0	5.4	143.0	4.0	199.0	5.4	144.0	3.9

NOTE: Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

trade, leaving the exchange of ideas and designs (services) as the prominent focus of trade. The level of gross trade is assumed to fall to 10 percent of GNP—approximately the level of trade in 1970. A deficit of natural resource and manufactured goods is balanced by exports of services.

4. The *Trend* case assumes 1984 levels of trade, but increases exports to restore the trade balance.

Table 13-2 indicates that the effects of these different cases tend to be isolated to a few sectors. The Caesar case succeeds in boosting manufacturing's share of jobs and GNP relative to the other trade assumptions, especially in the Medium and High Wage sectors. The main impact of the Drucker case is to boost the share of jobs and GNP appearing in the Low Wage Manufacturing sector—not surprising since a lower level of trade coupled with no change in domestic demand would effectively force businesses in this sector, such as textile and apparel firms, back "on-shore." As expected, the Banana case increases the Natural Resource sector's share of jobs and GNP while reducing the role of manufacturing.

Since balanced trade is a net generator of jobs, both cases with high levels of trade (Caesar and Banana) generate 4 to 5 million more jobs than the low-trade volume Drucker and 84-Base cases. Interestingly, the low-trade Drucker case generated as many jobs as the Trend, presumably because of the labor-intensive service industries created by Drucker. As was the case with domestic demand, however, the impact of the radically different trade cases on the structure of the economy is relatively small.

Production Recipes

Changes in the production recipe are considered in two parts: first, changes in the use of non-durable intermediate inputs for production; and, secondly, changes in the kinds of capital equipment purchased.

Intermediate Inputs

The complex changes in production recipes reviewed in chapters 4, 5, and 6 defy easy generalization. Three hypotheses are developed to explore ranges of reasonable possibilities:

1. The *trend* case is developed by extrapolating the changes in recipe occurring between 1972 to 1980 for an additional ten years. The general patterns of the trend were discussed in chapter 4. Inputs from natural resource and manufacturing sectors decline, and inputs from the service sectors, particularly Transactional Activities, increase. The trend case also results in a higher level of inter-industry transactions, indicating a more tightly linked economy that is a reflection of increased specialization.
2. The *stagnation* case assumes that production recipes remain fixed at 1980 levels.
3. The *alternative* recipe is based on the sectoral analyses of chapter 6. It resembles the trend case except that it is carried out 15 years further to 2005, and Natural Resource inputs to each sector are cut to 70 percent of their 1980 level—a reflection of the economy's reduced use of natural raw materials. Through the adoption of modern production techniques and a changing product mix, it is also assumed that the production recipe of the Construction, Low Wage Manufacturing, and High Wage Manufacturing sectors would increasingly begin to resemble the production recipes now used by Medium Wage Manufacturing.

   One-third of Medium Wage Manufacturing's production recipe change from 1980 to 2005 has been added to the 1980 recipe of each of these sectors, resulting in an overall increase of inputs, especially those originating in the Medium Wage Manufacturing, Transactional Activities, and Transportation & Trade sectors. A similar technique is applied to make education and the "paper pushing" parts of government behave more like Transactional Activities in the way they purchase inputs from the rest of the economy.

The results shown in table 13-3 indicate that the alternative recipe case postulates a much higher use of advanced technology, reflected in an increased role for Medium Wage Manufacturing, the need for more distributive and transactional services provided by the Transportation & Trade and Transactional Activities sectors, and a sharply reduced role for the Natural Resource sector. The trend recipe case proves to be roughly intermediate between the stagnation case and the alternative.

The alternative case creates 11 percent more jobs than the trend case, which in turn creates 6 percent more jobs than the stagnation case. This is because

Table 13-2.—Sensitivity Matrix of Jobs and Value-Added Under Different Scenarios of International Trade

	1984		Caesar		Banana		Drucker		Trend	
Production sector	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added
Natural Resources	4.5	9.2	4.4	9.1	4.8	9.8	4.3	8.9	4.3	9.1
Construction	4.5	6.2	4.1	5.7	4.1	5.7	4.1	5.8	4.1	5.8
Low Wage Manufacturing	4.5	3.2	4.8	3.5	4.6	3.3	5.2	3.9	4.5	3.3
Medium Wage Manufacturing	9.3	9.7	9.0	9.6	9.1	9.6	8.8	9.4	8.8	9.3
High Wage Manufacturing	5.7	9.2	5.4	8.8	5.3	8.6	5.3	8.8	5.0	8.2
Transportation and Trade	26.3	19.4	25.5	19.1	25.1	18.7	24.8	18.6	25.5	19.2
Transactional Activities	12.8	24.2	12.4	23.8	12.6	24.0	12.4	23.8	12.6	24.2
Personal Services	5.6	3.6	6.3	4.1	6.3	4.1	6.4	4.2	6.4	4.2
Social Services	26.8	15.3	28.1	16.3	28.1	16.2	28.6	16.6	28.7	16.7
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total jobs millions, GNP in trillions (1980$)	107.0	3.0	205.0	5.6	204.0	5.6	200.0	5.4	200.0	5.4

NOTE: Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

Table 13-3.—Sensitivity Matrix of Jobs and Value-Added Under Different Production Recipe Scenarios

	1984		Stagnation		Trend		Alternative	
Production sector	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added
Natural Resources	4.5	9.2	4.3	9.1	4.3	7.4	2.5	3.5
Construction	4.5	6.2	4.1	5.8	4.0	5.2	4.1	5.2
Low Wage Manufacturing	4.5	3.2	4.5	3.3	4.1	3.8	3.4	2.8
Medium Wage Manufacturing	9.3	9.7	8.8	9.3	8.9	9.6	10.4	12.0
High Wage Manufacturing	5.7	9.2	5.0	8.2	4.8	6.0	3.7	7.3
Transportation and Trade	26.3	19.4	25.5	19.1	27.3	20.0	30.8	21.0
Transactional Activities	12.8	24.2	12.6	24.2	13.3	28.4	13.5	31.8
Personal Services	5.6	3.6	6.4	4.2	6.1	4.3	5.6	4.1
Social Services	26.8	15.3	28.7	16.7	27.2	15.2	26.1	12.2
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total jobs millions, GNP in trillions (1980$)	107.0	3.0	200.0	5.4	212.0	5.4	235.0	5.4

NOTE: Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

the alternative and trend cases lead to increased inter-industry linkage and result in significantly greater demand for intermediate inputs from the comparatively labor-intensive service sectors.

Producers' Durable Equipment

Three producers' durable equipment composition cases have been constructed: a *trend* case, which extends the 1950 to 1985 trends out to 2005; a *manufacturing* case, which uses the 1972 pattern of investment to depict a surge in expenditures on industrial machinery; and an *information* case, which extends the 2005 share of computers, communication equipment, instruments, and photocopiers to 50 percent of all durable equipment expenditures.

Table 13-4 shows that the relative change attributable to these cases is small, with almost no difference between the information and trend cases. The major difference occurs in the manufacturing case, which increases the share of both jobs and GNP for the High Wage Manufacturing sector while lowering Medium Wage Manufacturing's share. This result is expected, given the emphasis on industrial machinery (a High Wage product) that reduces the share of equipment expenditures for information equipment (a Medium Wage product).

Labor Productivity

Not unexpectedly, a plausible range of assumptions about productivity translates into quite signif-

Table 13-4.—Sensitivity Matrix of Jobs and Value-Added Under Different Scenarios of Producers' Durable Equipment

	1984		Information		Manufacturing		Trend	
Production sector	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added
Natural Resources	4.5	9.2	4.3	9.1	4.4	9.1	4.3	9.0
Construction	4.5	6.2	4.1	5.8	4.1	5.8	4.1	5.8
Low Wage Manufacturing	4.5	3.2	4.4	3.3	4.5	3.3	4.5	3.3
Medium Wage Manufacturing	9.3	9.7	9.1	9.6	8.5	9.0	9.0	9.5
High Wage Manufacturing	5.7	9.2	4.9	8.0	5.1	8.4	4.9	8.1
Transportation and Trade	26.3	19.4	25.4	19.0	25.6	19.2	25.5	19.1
Transactional Activities	12.8	24.2	12.7	24.4	12.7	24.3	12.7	24.3
Personal Services	5.6	3.6	6.4	4.2	6.4	4.2	6.4	4.2
Social Services	26.8	15.3	28.7	16.7	28.8	16.7	28.7	16.6
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total jobs millions, GNP in trillions (1980$)	107.0	3.0	200.0	5.4	199.0	5.4	200.0	5.4

NOTE: Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

icant differences in the distribution and numbers of jobs.

- The *trend productivity* case assumes that the productivity growth rates established between 1958 and 1984 continue to 2005.
- The *high productivity* case assumes that trends prevailing between 1958 and 1972 are restored and continue between 1984 and 2005.
- The *low productivity* case assumes that the growth rates that occurred from 1973 to 1984 continue until 2005.
- There are two *alternative* cases. Both assume that productivity in the Construction sector follows the long-term (1958 to 1984) trend in productivity experienced in the Medium Wage Manufacturing industry; in other words, it is assumed that Construction will increasingly resemble manufacturing. The productivity of the Transportation sector is assumed to follow the low productivity path because of the increase in less-than-truckload hauling. The high productivity trend is used for the retail and wholesale trade (assuming the use of new technologies, such as scanners, and new processes, such as self service).

  Greater use of capital equipment (particularly computer and communication technology) is assumed to increase productivity in Transactional Activities and the government portion of the Social Service sector at a rate of 2 percent per year from 1984 to 2005. The productivity of the rest of the Social Service sector, consisting mainly of private health and education, is assumed to grow as it did from 1973 to 1984. The use of new technology is not assumed to change student-teacher ratios, but instead will change the *quality* of education in ways that are not normally measured (it will, for example, increase the productivity of a student's time). The high-alternative case assumes that the productivity of the Natural Resource, manufacturing, and Personal Service sectors grows at the high productivity rates through 2005; the low-alternative case assumes the low productivity rate for these sectors.

All of the cases shown in table 13-5 have higher shares of employment in the service sectors than in 1984, with the largest increases coming from the high productivity and high-alternative cases. This is undoubtedly the result of the much higher rates of productivity in the Medium and High Wage Manufacturing, Construction, and Natural Resource sectors as opposed to the service sectors. The modifications made in the alternative cases lower the share of employment in the Construction sector due to improvements in productivity, but indirectly increase the share held by manufacturing, largely because of gains in service sector productivity. In the low-alternative case, this assumption results in the highest share of High Wage Manufacturing jobs of any of the cases examined. (Since changes in labor productivity would not affect the amount of value-added generated, these calculations are not presented.)

Staffing Patterns

The remaining component examined is the occupational mix within each sector. Three cases were constructed:

Table 13-5.—Sensitivity Matrix of Jobs Under Different Scenarios of Productivity

Production sector	1984	Trend	High	Low	High-alternative	Low-alternative
Natural Resources	4.5	3.0	2.1	4.3	2.3	5.2
Construction	4.5	6.4	5.3	6.1	4.9	4.1
Low Wage Manufacturing	4.5	3.7	4.0	3.2	4.3	3.9
Medium Wage Manufacturing	9.3	7.8	8.6	6.8	9.3	8.3
High Wage Manufacturing	5.7	4.3	4.0	4.8	4.3	5.9
Transportation and Trade	26.3	23.7	21.6	25.5	25.3	21.4
Transactional Activities	12.8	13.5	14.3	12.6	13.6	11.5
Personal Services	5.6	5.8	5.4	6.8	5.9	8.4
Social Services	26.8	31.7	34.6	29.9	30.1	31.2
Total jobs (percent)	100.0	100.0	100.0	100.0	100.0	100.0
Total jobs (millions)	107.0	150.5	132.4	178.2	123.0	145.4

NOTE: Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

- a *stagnation* case, which assumes staffing patterns as they existed in 1984;
- a *trend* case, which extends changes that have occurred in staffing since the recession of the early 1980s to 2005; and
- an *alternative* case, based on the trend case, which makes modifications following the sectoral analyses of chapter 12.

As in the alternative recipe and productivity cases, the alternative staffing pattern case attempts to make Construction emulate a manufacturing concern by imposing the 2005 staffing pattern of High Wage Manufacturing onto Construction. Similarly, the staffing patterns of Low Wage and High Wage Manufacturing are made to resemble that of the Medium Wage sector by adding two-thirds of Medium Wage Manufacturing's 1984-2005 change to their 1984 staffing pattern. Medium Wage Manufacturing itself has been modified to reflect increased use of advanced manufacturing technologies by increasing the numbers of technical professionals and technicians, and by lowering the numbers of machine operators and precision production workers. The staffing patterns of the service sectors are changed to reflect a decrease in information distribution and processing occupations, based on the developments outlined in chapter 12. The number of people employed as "managers" are reduced by one-third and reclassified as "other professionals" in each service sector. This is based on an assumption that occupations growing out of new information technology will be both managerial and clerical in nature (akin to the para-professionals included in the "other professional" classification).

Because changes in staffing patterns do not alter the sectoral composition of jobs and GNP, it is necessary to look at the changes on the basis of occupations. Table 13-6 shows that the alternative and trend assumptions are somewhat similar and contrast sharply with the stagnation case. Under the alternative and trend assumptions, the share of managers, technical professionals, and sales workers rises while the share of education and health professionals, information distributors, precision production workers, machine operators, and farmers fall.

The differences between the trend and the alternative cases are in the size and not the direction of change. The alternative case produces more technical workers, "other" professionals, and transport workers, and fewer data entry & manipulation and precision production workers, than the trend case. Jobs for managers and sales workers also grow more slowly in the alternative case.

Table 13-6.—Sensitivity Matrix of Jobs Under Different Scenarios of Staffing

Occupation	Stagnation	Alternative	Trend
Managers and management support	10.6	13.5	17.3
Technical professionals	2.0	4.9	3.0
Education and health professionals	6.7	4.9	5.6
Other professionals	3.3	8.9	4.4
Technicians	3.0	6.7	3.9
Sales workers	10.5	13.4	13.7
Other customer contact	1.2	1.3	1.2
Information distribution	3.6	2.6	3.2
Data entry, manipulation, and processing	12.7	8.8	11.3
Food and beverage preparers	6.2	4.3	4.0
Other service workers	9.3	8.2	7.6
Precision production, craft, and repair	11.7	5.8	8.5
Machine operators, assemblers, and inspectors	7.6	5.6	5.2
Transportation and material moving	4.4	5.3	4.5
Handlers, equipment cleaners, helpers, and laborers	3.9	4.0	4.9
Farming, forestry, and fishing	3.3	1.7	1.7
Total jobs (percent)	100.0	100.0	100.0
Total jobs (millions)	200.0	200.0	200.0

NOTE: Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

Comparing the Influence of Different Factors

Table 13-7 shows the relative effects of all the factors just described when combined into the high-growth Trend scenario. While the magnitude of different factors varies widely between sectors, changes in productivity have the greatest influence on the change in a sector's share of jobs between 1984 and 2005. Lagging productivity is the primary reason for a gain in Construction's job share, while declining demand is nearly as powerful a factor behind High Wage Manufacturing's decline in job share. Although the Transportation & Trade sector would lose job share if the positive trend in productivity continued, the trend in the recipe of production substantially reduces the loss.

When staffing patterns are considered, however, even the productivity effects are overwhelmed by changes in staffing patterns *within* individual sectors (see table 13-8).

Table 13-7.—Change in Percentage of Job Share From 1984 to 2005 According to the High-Growth Trend Scenario

Production sectors	1 Job share shift	2 Productivity	3 Demand	4 Production Recipe	5 Interactive
Natural Resources	−2.4%	−2.2	−0.2	0.0	0.0
Construction	0.7	1.2	−0.4	−0.1	0.0
Low Wage Manufacturing	−0.8	−0.5	0.0	−0.4	0.1
Medium Wage Manufacturing	−0.6	−0.2	−0.5	0.1	0.0
High Wage Manufacturing	−1.9	−1.0	−0.7	−0.2	0.0
Transportation and Trade	−3.2	−3.9	−0.8	1.8	−0.3
Transactional Activities	2.3	1.6	−0.2	0.7	0.2
Personal Services	−0.4	−1.0	0.8	−0.3	0.1
Social Services	6.1	5.9	1.9	−1.5	−0.2

NOTE: 1=2+3+4+5. Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

Table 13-8.—Change in Percentage of Job Share From 1984 to 2005 According to the High-Growth Trend Scenario

Occupations	1 Job share shift	2 Demand	3 Production Recipe	4 Productivity	5 Staffing	6 Interactive
1. Managers and management support	7.3%	0.0%	0.1%	0.3%	6.7%	0.2%
2. Technical professionals	0.9	−0.1	0.0	0.0	1.1	−0.1
3. Education and health professionals	−0.2	0.5	−0.3	1.3	−1.4	−0.3
4. Other professionals	1.3	0.1	−0.1	0.4	0.9	0.0
5. Technicians	1.2	0.1	−0.1	0.3	0.9	−0.0
6. Sales workers	1.9	−0.3	0.6	−1.2	3.6	−0.8
7. Other customer contact	0.1	0.0	0.0	0.1	−0.1	0.1
8. Information distribution	−0.4	0.0	0.0	0.0	−0.4	0.0
9. Data-entry, manipulation, and processing	−0.8	0.1	0.1	0.9	−1.6	−0.3
10. Food and beverage workers	−2.4	0.0	0.2	−0.5	−2.2	0.1
11. Other service workers	−0.8	0.6	−0.3	0.8	−2.2	0.3
12. Precision production, craft, and repair	−3.1	−0.4	−0.1	−0.1	−2.8	0.3
13. Machine operators, assemblers, and operators	−3.0	−0.3	−0.2	−0.6	−2.2	0.3
14. Transportation and material moving	−0.3	−0.1	0.1	−0.3	0.2	−0.2
15. Handlers, equipment cleaners, helpers & laborers	0.6	−0.1	0.0	−0.1	1.2	−0.4
16. Farming, forestry, and fishing	−2.2	0.0	−0.1	−1.2	−1.6	0.7

NOTE: 1=2+3+4+5+6. Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

COMBINING COMPONENT ASSUMPTIONS INTO SCENARIOS

Constructing the Scenarios

The six scenarios described at the beginning of this chapter were constructed by combining assumptions from the set just described:

- The two *Trend* scenarios cluster assumptions extrapolating trends in domestic demand, international trade, the recipe of production, producers' durable equipment, labor productivity, and staffing patterns. These scenarios represent an effort to provide a reasonable extrapolation of trends established in the recent past.
- The *Manufacturing* case represents an attempt to describe a U.S. economy in which parts of traditional manufacturing enjoy a renaissance. This is done by coupling the Caesar trade scenario with capital equipment investments dominated by industrial machinery purchases. The trend projection for production recipes is used to reflect the shifting mixture of inputs as raw materials decline and services increase. The resultant output is converted to jobs via the high productivity scenario, and finally translated into occupations using the 1984 staffing patterns.
- The *Stagnation* case is designed to illustrate the effect of sluggish economic growth. It is constructed using the low-growth domestic demand trend, the low productivity trend, and the Banana trade scenario. The stagnation case keeps the recipe of production as it was in 1980, and maintains 1984 staffing patterns. The scenario assumes few changes except that trade is brought into balance as a result of large exports of natural resource materials such as foodstuffs, lumber, and coal.
- The two *Transformation* cases are designed to show what might happen if the economy undergoes a major transformation in consumption and production recipes of the type described in chapters 3 and 6. High- and low-growth rate cases are examined separately. The alternative scenarios are used for domestic demand, production recipe, productivity, and staffing patterns. The Drucker scenario is used for international trade, which assumes a low level of merchandise trade because of the world-wide diffusion of technology. In terms of capital equipment expenditures, the information scenario is used.

These assumptions are summarized in table 13-9.

Impact on Business Sectors

The structure of the U.S. economy resulting from these assumptions is displayed in table 13-10. As expected, the Trend scenarios continue the pattern of structural change discussed in chapters 5 and 10, while the Transformation scenarios result in a change in direction. With the exception of the Stagnation scenario (which postulates large foreign sales of resources), all of the scenarios result in a decline in the share of national output and employment generated by Natural Resource enterprises.

Taken together, the Nation's manufacturing enterprises hold a roughly constant share of GNP in all scenarios, although the sectoral mix depends heavily on the scenario.[3] The comparatively high

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[3] This finding is similar to that reported for the year 2000 by the U.S. Department of Labor. See Valerie A. Personick, "Industry Output and Employment through the End of the Century," *Monthly Labor Review*, September 1987, vol. 110, No. 9, pp. 30-41.

Table 13-9.—The Assumptions Used in the Scenarios

	Scenarios					
Assumption	Trend 3%	Trend 1.5%	Manufacturing	Stagnation	Transformation 3%	Transformation 1.5%
Domestic demand	Trend-3%	Trend-1.5%	Trend-3%	Trend-1.5%	Alternative-3%	Alternative-1.5%
Trade	Trend	Trend	Caesar	Banana	Drucker	Drucker
Production recipe	Trend	Trend	Trend	Stagnation	Alternative	Alternative
Producers' durable equipment	Trend	Trend	Manufacturing	Base-84	Information	Information
Productivity	High	Low	High	Low	High alternative	Low alternative
Staffing patterns	Trend	Trend	Stagnation	Stagnation	Alternative	Alternative

NOTE: See this chapter's text for definitions.

Table 13-10.—Sensitivity Matrix of Jobs Under Different Scenarios That Combine Various Assumptions

Production sector	1984		Trend 1.5%		Trend 3%		Manufacturing		Stagnation		Transformation 1.5%		Transformation 3%	
	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added	Jobs	Value-added
Natural Resources	4.5	9.2	4.4	7.7	2.1	7.4	2.2	7.6	4.9	10.2	2.8	3.2	1.1	3.1
Construction	4.5	6.2	6.2	5.4	5.2	5.2	5.2	5.1	6.3	5.8	4.3	5.5	4.5	5.3
Low Wage Manufacturing	4.5	3.2	2.8	3.6	3.7	3.8	3.9	4.0	3.1	3.2	3.4	3.2	3.7	3.4
Medium Wage Manufacturing	9.3	9.7	7.2	10.2	8.8	9.8	8.6	9.5	7.3	10.0	10.1	12.5	10.2	12.3
High Wage Manufacturing	5.7	9.2	4.8	6.0	3.8	5.8	4.3	6.6	5.3	8.7	4.5	7.4	2.9	7.1
Transportation and Trade	26.3	19.4	27.4	19.8	23.1	20.0	23.4	20.1	25.3	18.5	26.7	20.3	29.6	20.8
Transactional Activities	12.8	24.2	13.5	28.7	15.2	28.5	15.0	27.9	12.8	24.2	12.3	31.8	13.4	32.0
Personal Services	5.6	3.6	5.9	3.9	5.2	4.3	5.2	4.3	6.2	3.7	7.4	4.1	5.1	4.5
Social Services	26.8	15.3	27.7	14.7	32.9	15.2	32.3	14.9	28.7	15.7	28.6	12.1	29.5	11.5
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total jobs (millions), GNP in trillions (1980$)	107.0	3.0	135.5	4.0	139.7	5.4	142.3	5.6	130.3	4.1	122.6	3.9	156.4	5.4
Projected unemployment (percent)	8.6													
low labor force estimate (percent)			7.0		4.1		2.3		10.5		15.8		−7.4	
high labor force estimate (percent)			14.5		11.9		10.2		17.8		22.6		1.3	

NOTE: Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

technology Medium Wage Manufacturing enterprises hold a constant or growing share of GNP while High Wage Manufacturing loses share. Manufacturing as a whole actually increases its share of GNP under the Transformation scenarios.

While all the scenarios examined show manufacturing enterprises providing a shrinking fraction of jobs during the next two decades, the rate of decline remains well below that of the previous 20 years.[4] Manufacturing seems likely to provide 16 to 18 percent of all jobs by the year 2005. The next section suggests, however, that the nature of these jobs may change rapidly.

Although every scenario indicates that the share of value-added and jobs contributed to the economy by the service sectors is likely to increase, the size and composition of the contribution varies widely depending on the scenario chosen. The comparatively low rates of productivity growth in the Social Service sector, and increasing demand for health and other services contained in the Trend and Manufacturing scenarios, result in a significant increase in Social Services employment. Transactional Activities employment also grows sharply in the Trend cases because of relatively slow rates of productivity growth and the continuation of strong demand for their products. The sharp increases in service sector productivity evident in the Transformation scenarios reduce the share of jobs held by the Transactional Activities sector.

Impact on Occupations

Since all earlier analysis suggests that shifts of jobs *within* sectors has the greatest effect on the *kinds* of jobs provided by the U.S. economy, it is not surprising that the differences between the scenarios are most pronounced when measured by their impact on different occupations (see table 13-11). Unemployment rates, provided in table 13-10, are computed assuming high and low estimates of the labor force in 2005 of 146 and 158 million (see ch. 11 for details). The scenarios result in unemployment rates varying from 23 percent to minus 7 percent (implying a labor shortage).[5]

Composition

The scenarios lead to startling contrasts in the composition of the 2005 work force. For example, both the Trend and the Transformation scenarios lead to a situation where one out of every six or seven jobs is classified as managerial or management support, while the two cases that do not include an assumption about changing staffing patterns (Manufacturing and Stagnation) leave this category comparatively unchanged from 1984. In both the Trend and the Transformation cases, the number of people employed in occupations with comparatively low skills (food & beverage preparers and farm workers) decline. Many of these declining occupations are also some of the most dangerous occupations in the economy.

The difference between the Manufacturing and Stagnation cases and the other two cases is clearly visible in estimates of the future job opportunities for precision production & craft workers versus technicians and technical professionals. Both the Trend and Transformation scenarios indicate a decline in the production and craft workers and an increase in technicians. These findings are in rough agreement with forecasts made by the U.S. Department of Labor.[6]

The Transformation cases lead to a significant decline in employment for people who enter and perform routine manipulation on data (because of the assumed high rates of productivity growth in these occupations), and a doubling of the share of jobs held by technical professionals in 1984. The share of jobs called "other professionals" increases dramatically, due to the assumption that some managerial functions are reclassified and appear in this category. The

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[4] Again, the Department of Labor reached a similar conclusion in their projections. See Ibid.

[5] The upper range of OTA estimates of the labor force are higher than those projected by the Department of Labor because of OTA's larger projected population and higher assumed participation rates. This coupled with more extreme assumptions about productivity and production recipes result in a much wider future range of unemployment of −7 to 23 percent while the Department of Labor predicts a smaller range of 4.5 to 7.7 percent. See Howard Fullerton, Jr., "Labor Force Projections: 1986 to 2000," *Monthly Labor Review*, September 1987, vol. 110, No. 9, pp. 19-29.

[6] George T. Silvestri and John M. Lukasiewicz, "A Look at Occupational Employment Trends to the Year 2000," *Monthly Labor Review*, vol. 110, No. 9, September 1987, pp. 46-63.

Table 13-11.—Sensitivity Matrix of Jobs Under Different Scenarios That Combine Various Assumptions

Occupation	1984	Trend 1.5%	Trend 3%	Manufacturing	Stagnation	Transformation 1.5%	Transformation 3%
Managers and management support	10.6	17.3	17.9	10.8	10.6	13.3	13.1
Technical professionals	2.0	2.9	2.9	2.0	1.9	4.8	4.7
Education and health professionals	6.7	5.4	6.3	8.0	7.1	4.9	4.9
Other professionals	3.3	4.3	4.6	3.7	3.4	9.1	9.1
Technicians	3.0	3.9	4.1	3.3	3.0	6.6	6.7
Sales workers	10.5	14.4	12.9	9.6	10.1	13.8	14.8
Other customer contact	1.2	1.2	1.2	1.3	1.2	1.3	1.3
Information distribution	3.6	3.2	3.2	3.6	3.5	2.6	2.7
Data-entry, manipulation, and processing	12.7	11.3	12.0	13.7	12.8	8.8	8.9
Food and beverage preparers	6.2	4.1	3.9	5.9	6.2	4.5	4.8
Other service workers	9.3	7.4	8.0	10.2	9.8	8.5	8.0
Precision production, craft, and repair	11.7	9.1	8.5	11.2	12.0	5.8	5.6
Machine operators, assemblers, and inspectors	7.6	4.2	4.6	6.8	6.4	5.5	5.3
Transportation and material moving	4.4	4.7	4.1	4.1	4.4	5.2	5.2
Handlers, equipment cleaners, helpers & laborers	3.9	5.0	4.5	3.7	3.9	4.0	4.0
Farming, forestry, and fishing	3.3	1.7	1.1	2.1	3.6	1.3	0.8
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total jobs (millions)	107.0	135.5	139.7	142.3	130.3	122.6	156.4

NOTE: Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

Transformation cases do not lead to an increase in jobs for teachers or health professionals, because of the assumed growth in non-traditional aspects of health care and education (e.g. software development).

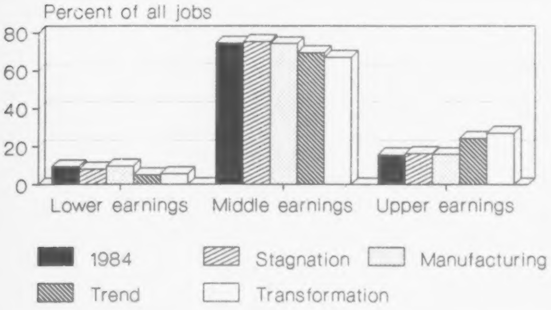
Turnover

The change in the skills needed by the U.S. economy in both the Trend and Transformation scenarios is dramatic. Only the Stagnation and Manufacturing cases result in a set of jobs matched to the skills in the work force today. The Trend and Transformation cases result in a 14 to 20 percent shift of employment between occupations—meaning that at a minimum, 14 to 20 percent of all jobs would be redefined during the next 20 years. Obviously, the high level of aggregation in the tables masks large changes in job definitions *within* categories such as "precision production worker" or "data entry worker." Some categories will be redefined by attrition as new workers enter with new skills and people with less needed skills retire. Others will be redefined by layoffs and new hires.

Earnings

If some of the scenarios suggest that a significant fraction of all jobs will be redefined in the next two decades, they also suggest that there will be a net decline in jobs traditionally paid low wages and an increase in the number of jobs that now pay high wages (see figure 13-1). While the Stagnation and Manufacturing scenarios leave income distribution comparatively unchanged, the Trend and Transformation scenarios lead to a decline in the percentage of people in occupations paying less than 66 percent of 1986 median weekly earnings, and a sharp increase in the percentage of people in occupations paying more than 133 percent of 1986 median weekly earnings.

Figure 13-1.-Earnings Distributions of Scenarios Based on 1986 Median Weekly Earnings by Occupation



NOTE: Lower group is 2/3s of the average, upper is 4/3s of the average, middle is remainder.

SOURCE: Office of Technology Assessment, 1987.

Educational Attainment

Given the correlation between income and education, it is not surprising that occupations dominated by people with no more than high school degrees decline in all the scenarios except Manufacturing and Stagnation (see figure 13-2). In both the Trend and Transformation scenarios, the share of all jobs in positions now held by people with four or more years of college increases while the share of jobs offered people with lower educational levels declines. The share of jobs available for people with four years of high school or less declines most sharply.[7]

Minorities and Women

The Department of Labor reports that blacks and Hispanics respectively account for about 11 and 7 percent of the labor force in 1986, but will make up 17 percent and 29 percent of of the total labor force growth between 1986 and 2005 (see table 11-2 of ch. 11).[8] Extrapolating from current statistics, the Labor Department estimates that minorities will be disproportionately employed in occupations that are projected to decline, such as machine setters and assemblers, and underrepresented in occupations estimated to increase, such as technicians and managers.[9]

With few exceptions, the occupations projected to grow now employ significant numbers of women while male-dominated jobs are in declining occupations. The major exceptions are the rapidly growing natural scientist, computer specialist, and engineering, architectural, & surveyor occupations, all now largely male. The share of jobs held by machine setters (42 percent female) is projected to decline.[10]

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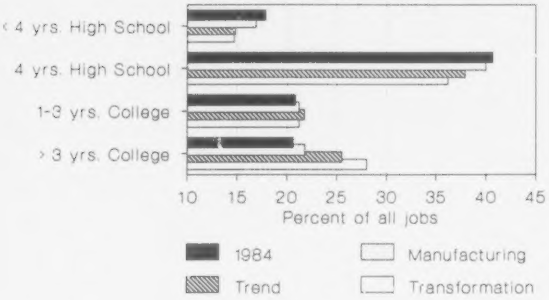
[7] A similar finding was reported by the Department of Labor in Ibid.

[8] H. Fullerton, op. cit., footnote 5.

[9] G. Silvestri and J. Lukasiewicz, op. cit., footnote 6.

[10] Ibid.

Figure 13-2.-Educational Requirements of Scenarios Based on 1986 Educational Attainment



SOURCE: Office of Technology Assessment, 1987.

At a Crossroads

These scenarios present stark contrasts for the future of the economy. Given continued productivity growth and freedom to transform production processes, the economy clearly has the opportunity to provide both real increases in amenity and a much improved mix of jobs. Changes in consumption and production recipes could even result in a net improvement when measured levels of economic growth are comparatively low. The analysis presented in chapter 3 reveals that the low-growth Transformation case can lead to improved levels of amenity—in respect to employment, the low-growth Transformation scenario could lead to a 16 to 23 percent unemployment rate given current working habits, but this could be reduced to 4 percent unemployment if the yearly number of hours worked declines 15 to 20 percent (e.g., a 35-hour work week).

Table 13-12 shows how the need for the basic amenities would be satisfied with respect to jobs by the various occupation classifications if the economy followed the path outlined by the high-growth Transformation scenario. Although many of the component assumptions that compose this scenario are rather drastic and tend to be exacerbated by the high rate of economic growth, they provide a rough indicator of the nature and magnitude of change that could occur.

The occupational composition of the amenities echoes the assumptions underlying the transformation scenario: technicians, technical professionals, sales workers, and managers play a larger role in almost every amenity group. Data entry and information distribution workers, precision production workers, and machine operators tend to decline in importance in all amenity groups. Compared to the patterns that prevailed in 1984 (see table 10-6 of ch. 10), the fraction of jobs in the education & health professional occupation drops significantly in the Health, Education, and Government amenity groups, and the share of work conducted by farmers is reduced in the Food and Export amenities.

Overall, the share of the employed workers dedicated to the production of the Food, Housing, and Export amenities declines while the fraction of all jobs that are needed to supply the amenities of Recreation and Leisure, Clothing and Personal Care, and Government increases.

Though not shown in table 13-12, every amenity requires less value-added from the Natural Resource sector and more from the Medium Wage Manufacturing and Transactional Activities sectors in 2005 than in 1984 (see table 4-6 of ch. 4). The magnitude of some of these potential shifts is sometimes startling: the fraction of value-added contributed from the Natural Resource sector to the Food amenity drops from 15 to 3 percent; the share of Construction value-added used to provide the amenity of Housing could fall by half; and the relative role of the Social Services sector in providing value-added to the Health, Education, and Government amenities could significantly decrease.

A Caveat

The probability of an economic future like that depicted in the high-growth Transformation scenario is low, but the probability of no change is even more unlikely. The preceding 12 chapters have outlined many changes that have been evolving steadily over time, like the shift from manufacturing to services, and some that are surprises, like the rapid diffusion of information technologies. In comparison to the last 15 years, many of the changes assumed in the scenarios for the year 2005 are conservative, but the analyses presented here must not be read as confident forecasts. They are *not* intended to be a comprehensive model of the U.S. economy. They are designed instead to illustrate how choices that affect different parts of the economy may affect the

Table 13-12.—Jobs Needed to Produce Amenity under the Transformation 3% Scenario, by Occupation

	Total	Food	Housing	Transportation	Health	Clothing and Personal Care	Education	Personal Business and Communication	Recreation and Leisure	Government n.e.c.	Federal Defense	Exports
Managers and management support	13.1	11.4	13.7	11.9	13.9	11.7	14.1	14.9	12.5	14.0	14.0	13.1
Technical professionals	4.7	4.7	6.5	4.7	3.6	4.6	4.0	7.3	4.0	4.5	4.8	6.1
Education and health professionals	4.9	1.3	1.7	2.0	10.3	1.4	9.8	2.7	5.1	8.0	7.3	1.3
Other professionals	9.1	6.3	10.0	7.6	10.6	6.8	10.3	13.5	9.5	9.7	9.2	6.7
Technicians	6.7	4.0	5.0	4.3	10.3	3.9	10.0	6.1	6.4	8.9	8.5	4.6
Sales workers	14.8	24.7	17.2	20.4	6.9	21.7	6.9	12.6	14.6	9.1	10.1	19.4
Other customer contact	1.3	0.9	1.6	1.2	1.3	1.1	1.3	2.3	1.5	1.3	1.2	0.9
Information distribution	2.7	2.6	2.6	2.5	2.9	2.5	2.9	2.7	2.5	2.8	2.8	2.6
Data-entry, manipulation, and processing	8.9	6.7	9.4	6.8	11.0	6.5	10.8	11.7	8.1	10.2	9.8	7.3
Food and beverage preparers	4.8	6.7	3.9	5.9	4.0	6.1	3.8	2.4	5.3	3.9	4.0	4.9
Other service workers	8.1	3.5	5.8	6.4	11.9	5.2	11.4	8.4	10.3	10.0	9.2	3.9
Precision production, craft, and repair	5.6	6.9	6.0	7.2	3.7	7.4	4.2	4.2	5.4	5.1	5.3	7.7
Machine operators, assemblers, and inspectors	5.3	6.5	5.8	6.5	2.8	8.1	3.6	3.5	4.9	4.5	5.3	8.5
Transportation and material moving	5.2	7.3	5.7	6.3	3.6	6.6	3.6	4.6	5.1	4.0	4.3	6.4
Handlers, equipment cleaners, helpers & laborers	4.0	6.0	4.3	5.5	2.1	6.0	2.3	2.6	4.0	3.0	3.2	5.6
Farming, forestry, and fishing	0.8	0.7	0.7	0.7	1.0	0.6	1.0	0.6	0.8	0.9	0.9	1.0
Total (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total jobs (millions)	156	19	18	12	19	14	16	7	21	12	13	5

NOTE: Numbers may not add due to rounding.

SOURCE: Office of Technology Assessment, 1988.

structure of the economy as a whole. The choices reflect decisions made by individual households, by producers, by people looking for work, and by government. The way government choice can influence the directions taken by the economy, for better or for worse, is the subject of the next chapter.

Chapter 14

Public Regulation and Incentives

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Chapter 14

Public Regulation and Incentives

THE CHALLENGE

New technologies and the expansion of economic networks around the globe have the potential to increase the welfare and promote the happiness of all Americans. The changes could:

- lead to rapid growth in the choices available to consumers;
- create unprecedented opportunities for communication, self expression, and entertainment;
- eliminate the least attractive jobs in the economy, and add large numbers of jobs that are rewarding in pay as well as in other ways;
- allow rapid economic growth without stressing the natural environment; and
- make training in any subject available to any person at any point during a career.

The new environment, however, also creates significant risks:

- Employers may attempt to achieve flexibility by avoiding long-term commitments to employees and hiring more temporary and part-time workers with little job security.
- There may be a growing gap between the kinds of jobs created by an economy capable of supplying a large fraction of its workers with good jobs paying high wages and the kinds of workers entering the work force.
- Failure to restore balance in U.S. trade accounts could trigger a trade crisis, undermining the economic security of the United States and its allies.
- The United States could become vulnerable to a sudden increase in world oil prices or a sudden disruption in oil supplies.
- Information technologies can be used in ways that threaten the privacy and independence of individuals in and out of the work environment.

There is nothing inevitable about either of these outcomes. The difference depends heavily on the choices made by American producers, investors, and consumers during the next few decades. These decisions are, in turn, heavily influenced by a complex network of Federal, State, and local rules and incentives. The question addressed by this chapter is whether the set of policies designed to promote growth and welfare in the United States, developed through accretion and tinkering over the last two generations, is well adapted to the current environment. In many cases the answer is no. An economy operating as an interlinked network may operate best with a set of rules that are very different from those which performed well for an economy built around well-defined production operations that acted in relative isolation. Programs that work well in a situation where products and production methods change comparatively slowly may be counterproductive in a world characterized by enormous uncertainty. Approaches to business sectors dominated by small, rapidly changing establishments—which may or may not be parts of a large firm—may be quite different from those designed to optimize the performance of an economy operating with a few dominant producers operating from large facilities.[1]

The policy opportunities discussed here are designed to provide a framework for developing a coherent set of programs to stimulate real growth throughout the economy, rather than being a detailed assessment of specific programs. The chapter follows the rules and incentives that influence the four crucial elements of all networks: consumption recipes (from Part I of this document), production recipes (Part II), trade in the production recipe (Part III), and people in the production recipe (Part IV). *A detailed analysis of the costs and benefits of specific policy opportunities is not attempted in the discussion that follows.* Instead, the material is divided into two parts. *The first part identifies a set of general objectives against which policy proposals should be measured.* These objectives are clearly traceable to issues identified in earlier parts of this document.

The second part of each discussion deals with specific options. None of these proposals have been analyzed in depth, nor has an attempt been made to provide a comprehensive list of options relative to

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[1] See the discussion in Michael Piore and Charles Sable, *The Second Industrial Divide* (New York, NY: Basic Books, 1984).

each objective; indeed, other such strategies could and should be considered. The examples are provided simply to illustrate the central thesis of the chapter: public choices made about the rules under which the U.S. economy operates have unprecedented power to determine whether the economy grows, and to guide the direction this growth will take.

Previous chapters argue that American's major economic networks are becoming more similar in the way they are managed, in the skills they look for from people at work, in the way they are affected by world trade, and in the way they are affected by financial markets. Nonetheless, each network remains unique in many ways. Each operates with a unique mix of public and private spending, and a unique set of regulatory controls and incentives. While opportunities for new policies are suggested by the separate discussions of networks in chapters 3, 6, 9, and 12, no attempt is made to summarize them here.

A FRAMEWORK FOR PUBLIC CHOICE

Consumption Recipes (Part I)

Objectives

The growing complexity of consumer choices were explored at some length in chapters 2 and 3. Consumer choices are becoming more complex as new technology and new patterns of competition increase the variety of products offered. At the same time, consumers may have less time to make informed choices.

Consumer choices are affected by public policy in four primary ways: regulations, deductions and credits in the personal income tax, product labeling, and consumption taxes (generally on "luxuries" and items like cigarettes and alcohol). Many of these policies were developed using paradigms that may need serious reexamination as the economy moves in new directions. The government, of course, is also a major consumer, spending nearly $30 for every $100 of private consumer expenditures. There are several areas where more sophisticated purchasing strategies by the government would not only improve the productivity with which public interests are served, but would stimulate innovation that could work to the benefit of private markets.

Education (largely supplied at public expense) also plays a critical role in shaping consumer choice. A good education can make a person aware of a greater variety of choices and improve the process of choosing. There is, for example, evidence that education can influence a person's ability to construct a "consumption recipe" for staying healthy. Similarly, it can allow a person to navigate the complexity of modern consumption decisions made massively more difficult by the new range of choices available. And it can open new opportunities for enjoyment (one of the traditional functions of education was to increase a student's ability to take pleasure from the culture that surrounded him).[2] Opportunities for improving education are discussed under the section on production recipes.

Illustrative Options

Regulation.—Regulation has been justified for a variety of reasons: controlling the abuse of monopoly power, preventing destructive competition in areas where there appeared to be a "natural monopoly," protecting public health and safety, and ensuring the availability of information in areas where the absence of information could be dangerous or where obtaining such information could be prohibitively expensive. Regulation has also been justified when the market does a poor job of allocating costs and benefits. Examples include: the maintenance of environmental quality, ensuring the safety of products, and ensuring that the United States does not become dangerously dependent on foreign sources of oil.[3]

The changes now transforming the economy undermine many of the reasons given for regulation to ensure effective competition, but increase the need to provide consumers with information, protect consumer safety, and ensure environmental quality.

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[2] "In the nineteenth and early twentieth centuries, education in the United States became universal, but it also become more and more a training in production skills and less and less a preparation for the enjoyment of life. Our puritan attitude and the requirements of our capitalist economy are equally to blame or credit . . . " Tibor Scitovsky, *The Joyless Economy*, (London: Oxford University Press, 1976), p. 229.

[3] For a comprehensive review of this subject, see S. Breyer, *Regulation and its Reform* (Cambridge, MA: Harvard University Press, 1982); and *Regulation: Process and Politics* (Washington, DC: Congressional Quarterly, Inc., 1982).

Regulating Monopolies and "Destructive" Competition.—Technology and other factors have reshaped production recipes in ways that appear to have reduced the danger of monopoly concentration. Regulatory restrictions have been sharply decreased in airlines, rail, trucking, long-distance telephone communication, and some aspects of banking. Regulatory reform may soon spread to other major business sectors. Private networks can bypass regulated telephone lines; onsite cogeneration units may compete with regulated producers of electric power; cable and video tape rentals compete with broadcast television (regulated through licensing).

Excessive regulation may prevent the emergence of business structures more compatible with emerging technologies, and may limit the ability of U.S. firms to compete abroad. Enthusiasm for reform must be tempered by the fact that structural change may well result in new kinds of monopoly manipulation of markets. It is unlikely that any simply or universal rule can be developed for prescribing regulations preventing the abuse of monopoly power.

Regulation to Supplement Consumer Information.—The cost of obtaining information for making informed consumer decisions may be on the rise, because the number and complexity of decisions are growing while the time available for making choices is in increasingly short supply. The cost of acquiring information needed to make wise purchasing decisions is part of the price (or the entertainment) of shopping. Some kinds of information, however, are prohibitively expensive to obtain—even though the information about such things as product safety may be of great value to the consumer. Few individuals can afford to pay for tests to ensure, for example, that food is not contaminated, or that children's clothing is not flammable. Passengers assume that airlines meet safety standards, and workers assume that the chemicals to which they are exposed have been tested to determine their health effects.

The net social value of informed consumer choice is large, since consumers are ultimately responsible for ensuring the efficient performance of free markets. The provision of information has always been an important function of regulation for this reason. In effect, consumers use regulation to buy collectively the information that would be difficult to buy as individuals. While ordinary markets could handle most such problems given negligible bargaining costs, this has not always occurred in important cases.[4]

Significant improvements could be made in the kind of information available to consumers through improved labeling. An alternative is taxes applied to specific products like cigarettes, alcohol, or gasoline, which force consumers to consider the social cost implicit in such purchases.

Unfortunately, there are no set rules about the kinds of information that should be provided at public expense. Information about the energy use of automobiles and appliances has clearly helped create a market for efficiency. Information about nutrition appears on food packages. There are many other areas where more information would be useful. Food labels may contain no information about potentially harmful components such as sodium, alcohol, cholesterol, saturated fats, or chemical contaminants. Energy consumption of homes and other aspects of housing quality remain a matter of conjecture for most home purchasers.

Personal Income Tax Reforms.—Spending decisions of individuals can be strongly influenced by Federal tax policy. In spite of major reforms, the U.S. tax code still contains long lists of consumer purchasing choices that are subsidized, or by default not subsidized, through tax relief. The net effect may not be appropriate for the emerging economy. Taking only a single example, the code places no limits on deductions for purchasing first or second homes (thereby encouraging savings in the form of home purchasing) but does not provide complete deductibility for education (thereby discouraging savings taken in the form of human capital).

Production Recipes (Part II)

Objectives

The challenges and choices faced by American producers were outlined in some detail in earlier chapters. It is clear that most people will need to endure a period of great uncertainty as deep structural changes undermine traditional production networks. It is not clear how Americans will elect to manage uncertainty. Two broad strategies seem possible. The first is to avoid commitments of any kind: keep investments in new plant and equipment to a minimum, minimize permanent commitments to employees, minimize investments in training, and wait for someone else to develop technology. The second strategy is to invest heavily in being "smart," with the aim of profiting in all kinds of economic environments. This means reacting quickly to exploit market opportunities, and moving adroitly when bad luck strikes. Such a response to uncertainty requires a well educated work force capable of prospering in a period of continuous change, and a strong long-term commitment to the development and exploitation of technology.

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[4] See discussion in S. Breyer, op. cit., footnote 3.

Much evidence suggests that while the second strategy may work well for some firms in some circumstances, the Nation's economy would be placed at considerable risk were it widely adopted. The choice between the two strategies will be strongly influenced by the rules established through tax law, support of innovation and invention, and other aspects of public policy.

Previous chapters also argued that the second kind of flexibility can be achieved using technology now entering the marketplace. Capturing this potential requires a willingness to undertake basic changes in the way businesses are managed, in the size and scope of individual establishments, and in the way establishments are linked together through formal and informal production networks. These changes will require some wrenching transformations, the effects of which can be measured in terms of job redefininition within firms, the opening and closing of plants, and changes in the location of productive activity. Constructive change requires both a continuous flow of innovation and a financial market willing to make the changes needed to convert these inventions into profitable products and services. An appropriate response to the challenges of new technology and expanded international competition requires highly flexible capital markets willing to rethink old paradigms about the design of business networks.

On the other hand, there can be too much of a good thing. There may be a narrow line separating a financial market capable of moving rapidly to restructure production around new processes, and one that has become a casino crippled by short-term speculation largely unrelated to the long-term health of a production enterprise. The challenge in designing policy is finding a way to encourage flexibility without sacrificing an ability to undertake research, marketing strategies, or restructuring plans that may pay returns only after many years.

Two major classes of public action in this area are discussed with these challenges in mind:

1. programs designed to improve the performance of U.S. financial markets; and
2. programs designed to create new incentives for innovation, which include a look at strategies to improve the Nation's infrastructure in ways compatible with the emerging economy.

Programs designed to improve the quality and productivity of the Nation's education and training activities are discussed in the section concerning choices for public policy concerning the U.S. work force.

Illustrative Options

Helping Financial Markets Work Better.—The central challenge in this area is finding a source of capital for projects that require continuity over a period of 5 years or more. Venture capital has proven to be an invaluable source of funds for small startup firms, supplying sums up to $20 or $30 million for new projects.[5] But venture capitalists cannot supply the $100 million required for a large manufacturing initiative. For this, companies must turn to public offerings and investors that generally demand competitive quarterly returns. This is perfectly satisfactory for low-risk ventures or ventures where losses can be cut quickly. It is not well matched to many of the kinds of investment that are needed to bring something like digital television to consumer markets, or to develop and market a 64-megabyte computer memory device. Such ventures require deep pockets and patience.

The concepts outlined below are designed to demonstrate that choosing to revise public rules can encourage a more dynamic response in the creation of new production strategies. The last of the three items on the list complements the set, attacking defects in rules governing both production and consumption recipes.

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[5] While supplies of venture money remain high in relative terms, in 1986 even American venture capital began moving away from technology-intensive products and moving sharply toward investments like discount shopping malls.

Tax Reform.—Revisions in the tax code during the 1980s, intended to increase savings rates and concentrate investment in innovation and research, have not achieved the effect once hoped for. Rates of savings and investment in new plant and equipment have not increased, while many indicators show that income inequality has grown during the past decade. Personal savings rates have actually fallen since 1981 and in 1986 reached their lowest level since the second world war. (This is due in part to the high rate of retained earnings in business—as a percent of GNP, the sum of personal and business savings has not changed significantly (see figure 2-4 of ch. 2).) Moreover, changes in the tax code, such as removal of the R&D tax credit, may have the effect of decreasing incentives to invest in research and innovation. The proposals sketched below have the common purpose of discouraging short-term, speculative investment and encouraging patient capital.

The tax code also provides a grab-bag of deductions that are essentially hidden expenditures, designed to encourage everything from housing to religious contributions. The value of these deductions rose from about one-quarter of Federal revenues in 1967 to one-half in 1983. These "hidden" appropriations were reduced in the 1986 tax reform, but are still enormous.

Proposals to reform the tax code would fill a small stadium. The following are exhibited to illustrate the power the tax code has in influencing the structure of the American economy. They are not a systematic review of alternatives and no effort has been made to explore their implications in detail.

- *Reducing taxes on high-risk, long-term personal investment.* Tax rates on capital gains could be changed so that gains realized on investments held for long periods of time (5 to 10 years) are taxed at much lower rates than gains earned on short-term investments. This could be done without affecting total revenues received from capital gains taxes.
- *Limitation of interest deductions for personal income to a fixed amount per family.* Interest deductions provide an incentive for homeowning. Without questioning the logic of subsidizing the housing expenditures of the middle class instead of expenditures in other areas, it is obvious that overly generous incentives can distort consumption decisions and encourage the affluent to invest in extravagant housing and multiple residences.
- *Reform or abolish the corporate income tax.* The corporate income tax has three principal virtues and many liabilities. It provides a source of revenue other than the ever unpopular personal income tax, it provides a way to influence corporate behavior to achieve a variety of goals, and it provides a way to tax foreign investors. These benefits carry a high price:
  - —The byzantine complexity of the corporate tax codes means that tax lawyers play a major role in mapping private investment strategies. The Tax Reform Act of 1986 will raise net corporate taxes and eliminate some of the distortions inherent in the older system, but this increase also raises the importance of skillful manipulation of tax law. Decisions distorted by tax considerations are likely to be less efficient than decisions motivated entirely by considerations of the risks and rewards of alternative products and production methods.[6]
  - —Corporate taxes do not result in a significant amount of income for government. In 1986, corporate taxes contributed only 10.1 percent of all Federal revenues and only 7.8 percent of all Federal, State, and local government revenues.
  - —The transactional costs of complex tax law are high, requiring many businesses to retain a small army of lawyers, accountants, and other professionals that adds to the unprofitable overhead of business activity.
  - —Corporate taxes also have the effect of discouraging savings taken in the form of corporate investment, since the income is taxed twice: once as corporate income, and once as dividends from the investment as personal income.

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[6] Auerbach estimated that the social cost of capital misallocation resulting from differential asset taxation was 3.19 percent of the corporate capital stock. See Alan J. Auerbach, "Corporate Taxation in the United States," *Brookings Papers on Economic Activity*, No. 2, 1983, pp. 451-513.

—The corporate tax can hurt U.S. exports. U.S. export prices include domestic taxes in the price of what is sold, while foreign competitors often use tax systems, like value-added taxes, that can be reimbursed if goods are exported.

Reform Regulation of Financial Institutions.—Restrictions on the operation of banks in the United States may no longer be consistent with the new demands of international competition and the capital requirements of innovative enterprises.[7] A majority of the world's largest banks are foreign-owned, in part because U.S. law limits interstate banking and may therefore discourage expansion. The Glass-Steagall Act of 1933 prevents firms that accept savings deposits from making equity investments or sitting on boards of directors. Merchant banks in Japan and West Germany, in contrast, provide important sources of patient capital. Japanese banks also benefit from relatively inexpensive capital, due to both high national savings rates and government sponsorship of certain classes of investment.

Reforms in this area might include:

- Revisions in banking law could create financial institutions better able to provide funds for projects that had outgrown venture funding but were deemed too risky for public holdings judged on the basis of quarterly returns. Banks could also provide a defense for firms that might be vulnerable to predatory takeovers because of heavy investment in long-term research efforts;[8] and
- Revisions in Labor Department regulations governing pension investments (funds that hold 22 percent of all U.S. corporate equities and 16 percent of all U.S. bond issues) could allow a fraction of the funds to be used for investments in innovations carrying higher risk.

Reducing "Transactional Costs."—Chapter 5 illustrated spectacular growth in the transactional "overhead costs" of the American economy that can result from unproductive speculation. But it is far easier to complain about transactional costs than to develop concrete steps to avoid them. The difficulty of measuring transactional costs means that changes in regulation may have the effect of reshuffling costs without actually affecting the total.

Strategies for reducing national transactional costs need careful review. Several of the steps suggested above, such as elimination of the corporate income tax or revision of formal regulations on price and market entry, could do much to lower unneeded legal, accounting, and other professional services. On the other hand, greater market freedom might also encourage more complex contracts and more lawsuits. Other ways to alleviate transactional costs include:

- A comprehensive review of tort law could determine how best to match formal safety regulations with legal redress open to individuals through the courts. Recent reforms, notably in California, have established new criteria for assigning liability costs—such as payment in proportion to contribution to proven negligence—and for limiting prohibitive punitive payments. The review could be analogous to the review recently conducted for Federal criminal law.
- Improving the efficiency of public services and channels for communicating with individuals, so that routine tasks such as access to data, title searches for property, or tax filings can be undertaken without professional assistance, is another possibility.

Support for Innovation.—Private support of research and innovation falls short of levels that serve the Nation's interest for a variety of reasons:

- Many kinds of long-term research (such as space exploration and basic research in areas like mathematics, chemistry, and biology) have no clear links to a company's "bottom line"; if they do, the payoff is so distant that few rational investors would be interested. Yet yesterday's basic research is the stuff on which today's productive innovation is based.
- Many sectors of the U.S. economy are so fragmented that no single firm has the competence or resources to undertake major research programs. Farming, the health industry, and the

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[7] For a comprehensive discussion of this issue, See U.S. Congress, Office of Technology Assessment, *International Competition in Services: Banking, Building, Software, Know-how*, OTA-ITE-328 (Washington, DC: U.S. Government Printing Office, July 1987).

[8] There is, however, little empirical evidence to support a contention that hostile takeovers are primarily directed at firms that engage in long-term planning. See J. Pound, K. Lehn, and G. Jarrell, "Are Takeovers Hostile to Economic Performance?" *Regulation*, September/October 1986, p. 25.

construction industry are obvious examples.

- Even the most technologically sophisticated businesses invest less in research than levels that could be justified to maximize collective wealth and social welfare, since no individual business is able to capture all possible benefits of the research.[9] Many domestic and even international competitors may enjoy some of the benefits of innovation, thereby reducing any one firm's net returns on an invention. While the Nation's interest is served, for example, by research designed to offset the effects of rapidly increasing oil imports during the 1990s, private planning horizons are typically too short to contemplate major long-term research in the area. Research in projects of common interest may go underfunded unless there is a social mechanism for sharing the costs and benefits of major classes of invention.
- Financial markets may be organized in a way that discounts the value of innovation and risk-taking when measured against speculative "paper" investment alternatives.

There is little doubt about whether public support of innovation is needed in these cases. There is little agreement about how this public support should best be provided. History is littered with failed government research projects—the Department of Energy's electric car; the Department of Transportation's Transbus; the Department of Housing and Urban Development's "Operation Breakthrough" in housing technology; the liquid metal, fast breeder reactor; and supersonic transport are some examples. It is possible to make major improvements in funding strategies because of the lessons learned from past experience. And there are success stories, as evidenced by the clear and continuing pipeline connecting innovation in federally supported agricultural and medical research laboratories with private manufacturers and practitioners.

Much can be learned from a close examination of successful foreign experiments. The Japanese have forged effective techniques for pooling corporate and government funds to develop and transfer technologies of mutual interest to participating firms, while leaving participants with proprietary protection in most areas. The Japanese semiconductor industry, for example, shared in the development of some chip manufacturing equipment needed by all participants, but manufacturers retained proprietary rights to the details of circuit designs.

Developing good ideas is necessary but not sufficient. Financial markets must be receptive to new ideas, and there must be a clear channel connecting publicly supported innovation with investors prepared to apply such efforts. These steps require businesses capable of grasping the implications of research results, and of collecting the resources needed to back such results with money and talent. As earlier discussion suggests, the transfer of technology is by no means certain in many critical parts of the economy.[10]

Apart from the programs to stimulate innovation through financial markets discussed earlier, government funding of innovation could take a variety of other forms, including the following.

A National Vision.—A set of national goals, including but not limited to national security, could focus public imagination on research and investment. Such programs might involve:

- development of technology permitting a *radical* improvement in the productivity (and fun) of education that would allow access to instruction for all, in virtually any subject, at any time during a career;
- development of a low-cost, high efficiency personal vehicle, which could replace the automobile in a world of expensive petroleum and possibly become a major U.S. export;
- support for ambitious scientific ventures, such as a series of unmanned probes of the planets or a permanent scientific station in space;

If such goals are accepted, they would provide a market for an enormous variety of innovations and private initiatives. Selection of the education "vision," for example, could stimulate private developments across a wide arena, including consumer electronics, software development, communications, basic research on artificial intelligence, and factors that contribute to learning and reasoning.

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[9] See Kenneth J. Arrow, "Economic Welfare and the Allocation of Resources for Invention," in National Bureau of Economic Research, *The Rate and Direction of Innovation Activity* (Princeton, NJ: Princeton University Press, 1962); R.R. Nelson, "The Simple Economics of Basic Science Research," *Journal of Political Economy*, vol. 67, 1959; E. Mansfield et al., "Social and Private Rates of Return From Industrial Innovations," *Quarterly Journal of Economics*, May 1977.

[10] See Fred V. Guterl, "Technology Transfer Isn't Working," *Business Month*, vol. 130, No. 3, September 1987, pp. 44-46.

Expanding the Use of "Engineering Research Centers" and "University Research Initiatives".—The Bell laboratories provided a unique mixture of basic research and corporate business interest under the shelter of communications regulation. This environment resulted in many of the inventions on which today's information revolution is based. In this regulated environment the laboratory had several key elements:

- it was able to attract some of the best people in the field,
- it was able to combine support of basic research with an interest in applied problems—in effect, basic problems were tackled by people predisposed to see practical applications,
- support was continuous, and projects could maintain continuity without the burden of a constant scramble for "soft" funding, and
- there was a critical mass of equipment and professional talent assembled on a single site.

The challenge here is to assemble a similar combination of elements in other areas, in order to spark both innovation and application. This quest is particularly important in areas lacking the luster of "glamour" technologies like superconductivity or artificial intelligence. The problems of manufacturing a building, automating apparel assembly, or improving information flows in an office may also be of vital importance to the national welfare.

Tax resources used to support industrial research and innovation should be considered a source of national savings, and not consumption. But it is treated as simple public consumption in official accounts, and in the minds of most people who think about the use of government funds. Properly managed Federal investment in innovation is likely to pay rich rewards to the Nation as a whole. Untraditional sources of income could be sought for subsidizing such research. The Japanese, for example, use receipts from national bicycle racing to support research.

Combining public and private funds not only amplifies the effect of public spending. It can ensure that research priorities are set in a way that allows graceful transfer of collective research to proprietary products—a development that can have a positive impact on the productivity of both individual businesses and entire industries. Several models are available, including:

- The National Science Foundation (NSF) has funded 13 Engineering Research Centers (ERCs) (similarly, the U.S. Department of Defense is contemplating a University Research Initiative). These provide a useful model for such programs, even though total funding remains low; the ERC program was funded at $30 million in fiscal year 1987, and the entire NSF Engineering Directorate had a budget of $163 million.
- Trade associations like the Electric Power Research Institute (EPRI) may provide a good model for pooling research funding in fragmented businesses. EPRI is funded primarily through voluntary contributions from member companies, which include public utilities, and matching Federal funds are sought for certain specific projects. Many other business sectors have trade associations that might serve as a good foundation on which to build jointly funded research programs, for both production and non-production sectors in the U.S. economy.
- The National Laboratories could also provide a sound technical base for applied research, if their civilian programs could be expanded and properly managed.
- Massachusetts, Michigan, and several other States have programs that in effect mingle private and public funds for investments in new ventures.

Another approach to public support of innovation is to hope that funding for defense-related research will "trickle down" to civilian industries. While the United States spent 2.8 percent of its GNP on research in 1986, a fraction only slightly higher than the amount spent by Japan, West Germany, and other major industrial nations, over 69 percent of U.S. research spending goes for defense-related research—this compares with (as of 1984) 50 percent in the United Kingdom, 30 percent in France, 10 percent in West Germany, and 3 percent in Japan.[11] The fraction of all Federal research spending going for defense fluctuated between 48 and 54 percent during the 1970s, but climbed sharply in the 1980s (see figure 14-1).

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[11] U.S. Congress, Congressional Research Service, "The Federal Contribution to Basic Research," CRS 87-633 SPR, July 23, 1987, table 12.

There is a longstanding debate over the extent to which defense research is an efficient way to ensure innovation in the civilian economy.[12] There is evidence that the rapid military buildup of the 1980s did not place a major burden on overall supplies of engineers;[13] it is obviously difficult to determine whether defense projects have attracted the best graduates. But there is evidence that civilian applications of defense research are difficult to find. While 13 percent of the patents generated by the U.S. Department of Agriculture are licensed by private firms, only about 1 percent of Navy patents are so licensed.[14]

The U.S. Department of Defense (DoD), concerned by the lack of innovation in the civilian economy, has begun to take direct action. Concerned about the rapidly growing dependence of DoD on foreign sources of semiconductors, a task force of the Defense Science Board recently found that U.S. defense industry relied heavily on products purchased from worldwide commercial markets. This group expressed concern that declining non-military sales of U.S. technology firms often left the United States with a Hobsen's choice: "buy foreign" or "buy second-best." The task force concluded that

> *The major reason for the relative inadequacy of technology development in the United States vis-a-vis that in Japan has been the difference in the industrial policies and structure of the two countries* [emphasis in original document].

They went on to state that DoD could move rapidly to:

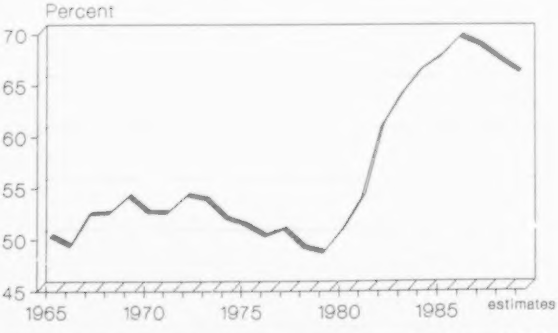
> 1. *Support the establishment of a semiconductor manufacturing technology institute*, 2. *Establish at Eight Universities Centers of Excellence for Semiconductor Science and Engineering*, 3. *Increase Department of Defense spending for research and development in semiconductor materials, devices, and manufacturing infrastructure*, 4. *Provide a source of discretionary funds to the Defense Department's semiconductor suppliers*, 5. *Establish under the Department of Defense a Government/Industry/University forum for semiconductors* [emphasis in original document].[15]

In part responding to this recommendation, the Secretary of Defense initiated a "Department of Defense Initiative on the U.S. Industrial Base," designed to:

> . . . effectively pursue a DoD strategy to support the fundamental goal of U.S. technological and manufacturing leadership and world class capability. The strategy will explicitly recognize that potential solutions will fall within two basic categories. First, those for which DoD has a direct responsibility and which can be pursued within the full potential of DoD policies and programs. Second, those for which the responsibility falls elsewhere in the Government and for which DoD must attempt to lead and/or influence other agencies' consensus to revitalize the U.S. technological and manufacturing base.[16]

There is clear consensus on the need to ensure a competitive and vigorous civilian economy in order to maintain a sound defense. There is less agreement about whether a strategy directed primarily by defense objectives is an adequate substitute for ci-

Figure 14-1.-Defense Research and Development Funding (as a percent of all federal research and development)



SOURCE: M.E. Davey and Genevieve Knezo, "The Federal Contribution to Basic Research," U.S. Congressional Research Service report No. 87-633-SPR, Washington, DC, July 23, 1987, table 12. Updated for 1987 and estimates for 1988 and 1989 by the National Science Foundation, data provided by the Congressional Reference Service, Mar. 9, 1988.

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[12] See a review in U.S. Congressional Budget Office, *Defense Spending and the Economy* (Washington, DC: U.S. Government Printing Office, 1983).

[13] Panel on Engineering Labor Markets, National Research Council, *The Impact of Defense Spending on Nondefense Engineering Labor Markets* (Washington, DC: National Academy Press, 1986).

[14] F.R. Lichtenberg, "Military R&D Depletes Economic Might," *The Wall Street Journal*, Aug. 21, 1986.

[15] Defense Science Board, "Task Force on Defense Semiconductor Dependency" (Washington, DC: U.S. Government Printing Office, December 1986).

[16] Memorandum from the Secretary of Defense, "Manufacturing, Industrial Base, and Competitiveness," Washington DC, May 5, 1987.

vilian programs. Obviously, the two should be coordinated. Whatever mechanism is used, it is critical that no institution gain a monopoly on research.

Making Government More Efficient as an Information Enterprise.—The Federal government is one of the Nation's largest information-based enterprises. Outside of defense, the Federal government directly employs 3 percent of the Nation's work force. State and local government employees (other than those employed in education) represent another 6 percent. Most government workers are in the business of gathering, communicating, or processing information in one way or another. Research and investment directed at making this process more efficient could not only improve government efficiency, but could provide an information base of value to other enterprises.

Wisely managed Federal procurement could create a market for a variety of service sector innovations, and could force the adoption of standards, protocols, and conventions that might facilitate the formation of a market for service sector technologies. Given the important role that productivity increases play in establishing patterns of international trade, wages, and economic growth, and given the fact that the service sector represents a huge portion of the U.S. economy, improved productivity in this area would be of direct benefit to governments—as well as to consumers and businesses. The national accounts themselves may be a barrier to clear thinking in this area, since they treat all funds spent to improve productivity in government as consumption and not as investment.[17]

A Careful Review of Priorities for Federally Supported Loans and Borrowing.—The Federal Government now allocates much of its $200 to $300 billion in loan accounts to the housing and agriculture industries. But in 1983, the government lost at least $8.4 billion in tax income by subsidizing loans through the Rural Electrification Administration, the Farmers' Home Administration, the Commodity Credit Corp., farm export credits, foreign military sales credits, and other programs; such losses continue to plague the entire farm finance system. An approximately equal amount was lost through loans for subsidized housing, student loans, tax-exempt industrial development bonds, and other tax exemptions for private purposes. Approximately $59 billion in tax credits for investment were claimed.[18]

It is reasonable to ask whether these largely hidden costs are appropriate, given the areas most likely to stimulate national economic growth. At a minimum, there should be a clear accounting of public spending that results directly and indirectly from these programs but escapes the scrutiny of annual appropriation.

National Competitions.—In many cases, innovators within large firms are unable to move an idea from the laboratory into a fully developed product because they cannot guarantee a market. One way to avoid this problem would be to run a series of publicly sponsored competitions for the development of specific products or software capabilities. The government could establish a series of generic application procedures, and could encourage businesses to submit designs. The winner might be given a cash reward, and the government could either purchase the initial production run at an agreed price or subsidize its sales price.

Other competitors finishing near the top might have the cost of their research covered. For example, if the project covered the cost of an innovative, highly efficient automobile, the government could pay a manufacturer the difference between $20,000 and the manufacturer's list price for the first 10,000 vehicles meeting the performance specification sold to the public at a price between $6,000 and $6,500.[19] If the concept worked, the government would have encouraged development of a new product with minimal interference, at a total cost of less than $140 million.

It might also be useful to consider introduction of significant awards for individual researchers or research teams, which could permit specially talented groups to pursue a line of research comparatively free of interruption for 5 years. Such research could be in areas of importance to both manufacturing and service enterprises, aimed at improving the performance of the integrated networks linking all U.S. producers.

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[17] Robert Eisner, "The Federal Deficit: How Does it Matter?" *Science*, vol. 237, No. 4822, Sept. 25, 1987, pp. 1577-1582.

[18] Herman B. Leonard, *Checks Unbalanced: The Quiet Side of Public Spending* (New York, NY: Basic Books, 1986).

[19] This was proposed by Battelle Laboratories in 1982.

International Trade Policy (Part III)

Objectives

U.S. and international production networks are now tied together in intricate ways. This includes large-scale flows of financial resources, production and supply networks linked through sophisticated communications and transportation systems, and even interconnected design and research projects. World debt (including the U.S. foreign debt) has become a global problem, transcending national borders.

The clear objective of U.S. trade policy should be to create an international trading environment that can do what economists have always claimed it could do: raise living standards among all trading countries simultaneously. It is obvious, however, that while trade has generally served both the United States and its trading partners well, the international market is far from free. The United States faces vigorous international competition from firms supported by their home governments, and America may have as many, if not more, trade barriers than many of its competitors. There is reason to believe, however, that other nations have benefited more from their management of trade than has the United States because of the skill with which they have pursued this strategy.

U.S. trade policy has often been conducted in virtual isolation from domestic policy. The trade policy that exists has all too often been limited to quota protection for business sectors with strong political support. The consequences on U.S. trade of changes in domestic programs for communications, banking, agriculture, or other sectors are often not given adequate attention. Given the expansion of the U.S. economy into international production networks, these issues can no longer be ignored.

It is unlikely that any unilateral U.S. action can succeed in transforming the world trading system in ways that allow for the benefits inherent in a freely operating world trading system. Indeed, international links severely constrain the extent to which the United States can control its own economy. Standard Keynesian strategies for stimulating demand can result in increased imports instead of new domestic jobs. Monetary strategy can be frustrated by international capital flows. Designing domestic tax programs will become increasingly difficult as firms around the world develop complex relationships with each other.

Only collaborative efforts involving both advanced and underdeveloped nations are likely to create a trading regime consistent with the broad objective of making trade a "positive sum game" for all nations, and stimulating rapid growth in the world economy. There is no simple way to accomplish this; there can only be painstaking and skillful bargaining in a variety of international forums. Success will require intelligence and endurance.

Calls for greater coordination are obviously not new. Any effort to encourage nations to cooperate on matters so closely tied to domestic political programs is likely to encounter enormous obstacles, such as nationalism and conflicting domestic priorities. Yet the need for coordination grows more important as the economies of the world become ever more interconnected. Inward-looking national fiscal programs that work at cross purposes are likely to grow steadily more dangerous. The need to coordinate foreign economic assistance, banking, and trade policy provides a major example. The best long-term solution to third world debt is to help them become prosperous trading partners. This will require intelligent coordination of policy throughout the developed world.

U.S. leadership in this area is crucial. This leadership, of course, depends on the development of a coherent strategy patiently administered.

Illustrative Options

It is extremely difficult to separate programs designed to improve the performance of the domestic economy from those designed to improve the U.S. position in international markets. Most of the programs described in this chapter are focused on creating an environment where the American economy can grow and prosper by building around a new set of opportunities introduced by technology. Renewed growth in national productivity, and the need for flexible response to new opportunities, are of critical importance if the United States is to improve its living standards and compete successfully in international markets. At the same time, it is clear that domestic policies leading Americans to consume more than they produce are related to current U.S. trade deficits. While tracing causes and effects is difficult and controversial, it is obvious that trade policy cannot be separated from domestic fiscal policy.

Examples of projects applying specifically to trade include, but are certainly not limited to, those outlined below.

Improved Coordination of OECD Banking and Fiscal Policies.—Until very recently, there has been more rhetoric than reality in programs for controlling wild fluctuations in exchange rates, and little serious effort to guarantee that U.S. and foreign macroeconomic policies are not working at cross purposes. But the sheer volume of international trade has now made it impossible for a nation to alter its domestic economy without considering the potential reactions of trading partners. Moreover, international firms have developed great facility in moving assets in ways that can frustrate the efforts of a nation acting alone. Currency traded in private markets, for example, can overwhelm currency purchases by central banks.

If national fiscal and monetary policies are not coordinated, each nation will find its efforts to regulate its economy increasingly frustrated. The Basel Committee offers a framework for coordination of banking policy,[20] while recent actions taken by the "group of seven"—the United States, Canada, Japan, France, West Germany, Great Britain, and Italy—to control currency fluctuations could also be built upon.

Increased Efforts to Develop Cooperative Research Projects.—The problems the United States faces in improving education, health care technology, or transportation networks are not unique. A revolution in education technology or rapid progress in pure scientific research would benefit all nations. Significant efficiencies could be achieved from greater use of international funding for research projects with benefits likely to be of universal value.

Export Promotion Activities.—A variety of techniques are available for using national resources to promote U.S. exports. If nothing else, personnel in overseas missions can keep U.S. producers abreast of the complex regulations and procedures that must be understood to complete transactions in foreign markets. This is particularly helpful for small businesses, which are often unfamiliar with practices abroad and unable to invest in a large staff to follow such issues. In West Germany, trade associations have helped small firms to pool resources and bid on overseas projects. It would be possible to provide direct Federal support for such efforts among U.S. enterprises.

The Agricultural Information and Marketing Service, operated by the U.S. Department of Agriculture, runs a computer database that includes current and highly specific information on potential foreign markets. A surprisingly large fraction of successful U.S. farmers now own personal computers, and this project appears to be a success. The concept might be useful in other markets.

Subsidies for Language Training, Translation, and Education.—One problem faced by U.S. exporters is their sheer ignorance of the nature of foreign markets—ignorance magnified by a widespread inability to speak any language but English. While it may once have been true that products made in America virtually sold themselves, combining quality with an image of being at the cutting age of taste and technology, in many areas this is no longer the case. While many U.S. firms still demonstrate a reluctance to learn about developments in other countries,[21] sales abroad depend as never before on understanding foreign cultures, tastes, and business practices. There is an unpleasant history of U.S. firms failing in attempts to sell large refrigerators to countries with tiny kitchens or blond-haired dolls to African or Asian nations.[22]

Successful exporting depends increasingly on an understanding of the history and culture of the people with whom U.S. firms expect to trade. Understanding could be facilitated through expanded support for programs designed to send U.S. students abroad for study, and increased funding for joint research programs that involve close working relationships between U.S. and foreign engineering and scientific staffs.

Temporary Tariff Protection.—The merits of protection have been hotly debated in the United States at least since Alexander Hamilton's *Report on*

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[20] See *International Competition in Services*, op. cit., footnote 7.

[21] Clay Chandler, "U.S. Industry Cool to Japan's High-Tech Publications," *The Washington Post*, Sept. 8, 1987, p. D1.

[22] C.H. Deutsch, "U.S. Industry's Unfinished Struggle," *The New York Times*, Feb. 21, 1988, sec. 3, p. 1.

the Subject of Manufactures argued for the protection of "infant" U.S. industries. Protectionism typically penalizes low-income groups by imposing an implicit sales tax on many essential goods, while benefiting specific workers, regions, and industries.[23] There is considerable debate over whether the cost of saving a job through protectionist measures is higher than alternative methods of job generation.[24] The political dilemma, of course, is that the consumer tax implicit in protection is effectively hidden while direct taxation to promote education or training, and therefore competitiveness, is extremely visible.

Protectionist measures can also be damaging to long-term U.S. interests if they have the effect of diminishing incentives for invention and innovation. In principle, U.S. markets are so large that vigorous competition among domestic firms would be likely even if foreign firms were excluded. In practice, however, comfortable domestic arrangements have often blocked the effective operation of domestic competition. Prior to sharp competition from abroad, for example, U.S. automobile companies vied with each other primarily over styling and not over price, quality, or efficiency.[25] Foreign entrants into the automobile industry demonstrated that real improvements in quality and performance could be made, and thereby provided urgent incentives for U.S. automobile manufacturers to match their performance.

Arguments in favor of increased protection have come from affected industries and employees, and from a group of trade theorists who argue that government intervention can shape an environment in which firms make strategic decisions affecting trade.[26] They argue, for example, that if an innovator can capture "super-normal profits" by being first with a new technology, the government can help domestic firms maintain comparative advantage in areas where such benefits can be captured.[27] It could do this by subsidizing domestic research and the dissemination of this research, and by protecting domestic markets in ways that would give domestic firms an opportunity to reduce costs by perfecting techniques. This learning would allow them to enter foreign markets with costs lower than their competitors and thereby to move rapidly in capturing market shares. This success itself may deter competitors from entering the market.[28] The fact that the U.S. government would be willing to undertake such a strategy might deter other nations. The Japanese record in implementing a strategy of this sort has been reported as both a success and as a failure. It appears that the Ministry of International Trade and Industry has made a number of costly mistakes as well as championing several successes.[29] As outlined earlier in this chapter, of course, support for domestic research can be justified for many reasons other than its potential impact on the competitiveness of domestic U.S. firms in international markets.

To the extent that explicit protectionist measures can be justified, the cost of tariffs appears to be significantly lower than that of non-tariff protection for a variety of reasons:[30]

- Protection necessarily raises the price of goods sold to domestic consumers, but tariffs ensure that this price increase is captured by the United States. Quotas allow foreign producers to raise prices or change product mixes, and the price differential is left primarily in foreign hands.
- Tariffs retain competitive pressure on domestic producers to promote continuous progress in efficiency, and protect consumers against price increases that might be taken by monopoly suppliers under the shelter of the quotas.
- The cost of tariffs is clear and visible to the public, while quotas make the price consumers pay for trade protection difficult to see.

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[23] Susan Hickok "The Consumer Cost of U.S. Trade Restraints," *Federal Reserve Bank of New York Quarterly Review*, summer 1985, pp. 1-12, cited in World Bank, *World Development Report*, Washington, DC, 1986.

[24] U.S. Congress, Office of Technology Assessment, *Technology and Structural Unemployment—Reemploying Displaced Adults*, OTA-ITE-250 (Washington, DC: U.S. Government Printing Office, February 1986).

[25] Ian Altschuler, et al., *The Future of the Automobile: The Report of MIT's International Automobile Program* (London: George Allen & Unwin Publishers Ltd., 1984).

[26] Anne Krueger and Baran Tuncer, "An Empirical Test of the Infant Industry Argument," *The American Economic Review*, vol. 72, No. 5, December 1982.

[27] James A. Brander and Barbara J. Spencer, "Export Subsidies and International Market Share Rivalry," National Bureau of Economic Research, working paper No. 1464, Cambridge, MA, 1984; and David J. Richardson, "International Trade Policies in a World of Industrial Change," in Federal Reserve Bank of Kansas City, *Industrial Change and Public Policy*, 1983, p. 286.

[28] Federal Reserve Bank of Kansas City, op. cit., footnote, 27, p. 287.

[29] Ira Magaziner and Thomas Hout, *Japanese Industrial Policy* (Berkeley, CA: University of California, Institute for International Studies, 1980).

[30] See Robert Lawrence, *Can America Compete?* (Washington, DC: The Brookings Institution, 1984).

Improving the Flexibility of People at Work and the Quality of the U.S. Work Force (Part IV)

Objectives

Part IV paints starkly contrasting possibilities for the future of working life in America. The economy could expand by building on the talents of employees in jobs that permit greater freedom to work on a continuously changing set of products and problems. On the other hand, tomorrow's workplace could be built around disposable employees, as employers avoid any commitment to workers in the form of expected job tenure and any investment in the form of education or training. Many firms now maintain flexibility by using comparatively large numbers of temporary and part-time employees, minimizing commitments to employees in the form of retraining, and undertaking change largely through layoffs and early retirements. There could be a major mismatch between labor supplies (many new workers are likely to be members of minority groups with comparatively poor educations) and growing demands for well educated workers (see ch. 11).

Objectives for policy designed to improve the performance of people in the production recipe, therefore, include the following:

- ensuring a well-trained work force, in which the skills of those needing jobs are appropriate for the employment opportunities that will appear over the next two decades;
- compensation systems that maintain incentives and improve the match between compensation and individual contributions to insurance and retirement plans, while avoiding any unhealthy growth of inequality in the distribution of national income;
- achieving a level of job security that does not strangle the mobility and flexibility necessary in the emerging U.S. economy;
- helping two-earner households and single parents gracefully combine the responsibilities of child raising with a working life; and
- providing adequate safeguards for health and safety in the workplace.

Illustrative Options

The discussion that follows explores ways of encouraging business owners to increase their commitments to employees, instead of trying to achieve flexibility through a constant series of layoffs and rehirings. The options also reflect ways of affecting the overall framework of people in the production recipe, encouraging the use of training and experience by subsidizing supplies of skilled individuals.

A Learning Research Institute.—There is no enterprise more critical to the Nation's future than its system of education. Education is a major part of the U.S. economy, employing 8 percent of the work force. Yet educational enterprises are organized in a way that frustrates attempts to make basic changes in the productivity of the educational process. It is often assumed that there can be no efficiency gains from capitalization of employees, or from basic changes in management strategies of delivering educational services. Both assumptions may be wrong. Unfortunately, few levels of management appear capable of even questioning the educational process.

Much of the educational system is, in effect, a series of isolated fiefdoms built around individual school systems, if not individual classrooms, that communicate ineffectively. One symptom of the inefficiency of the system performing as a whole can be seen by examining investments in research as a fraction of gross receipts. If the Nation's educational enterprises invested in research and development in the same proportion to gross receipts as the average U.S. industry, investment would have amounted to between $8 and $12 billion in 1985—60 to 90 times more than the actual total.[31] Although the National Science Foundation, the Department of Education, the Department of Defense, and some of the more affluent States have made modest investments in improving the process and the technology of education, support and management of the sum total of such programs seems incommensurate with the critical importance of the improvements. At one time, it might have been argued that no technology was available for attacking the basic problems of productivity of teachers or learners. But technologies now entering the market have made this assumption obsolete.

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[31] In 1987, the U.S. Department of Education and the National Science Foundation spent approximately $130 million on research and development in education. This is approximately 0.06 percent of total government spending on education and 0.025 percent of all spending on education. As a nation, the United States spends roughly 2.5 percent of GNP on research and development.

While the potential for technological improvements in education exists, the institutions available to evaluate innovation, and to examine the radical changes in management that may be needed to exploit this potential, seem inadequate to the task. One possible remedy, designed in part to highlight the importance of the problem, would be to create a new institution with a clear charter to improve the productivity of teaching and learning throughout the U.S. economy.

Several models could be considered. One would be an independent "Learning Research Institute," managed in much the same way that the National Institutes of Health are managed and sheltered from political change to the greatest extent possible. Lessons learned from research institutes in other areas could be used to construct a charter that would provide the greatest possible insulation from political manipulation while ensuring that the system was responsive to the needs of its clients—the Nation's students and teachers.

The Institute's charter could include K-12 schooling, post-secondary education of all kinds, and training and retraining programs. Its responsibility could be the development of a range of new teaching strategies making appropriate use of information technology. Programs might range from active research in techniques of pedagogy to strategies for managing instruction in the classroom, at home, and in business settings. This public resource could also make major investments in the development of instructional software, appropriate for such areas as public television programming or the learning of ambitious teaching systems based on technologies likely to be available over the next two decades. And since the problems confronted by such a program would be of international interest, it is likely that the project would attract strong international support (see the discussion of cooperate international research programs earlier in this chapter).

Subsidies for Education Beyond High School.—It seems possible to increase the productivity of schools to the point where most students would have the equivalent of 2 years of college education by the time they reach the age of 18—the age at which they are still supported by public education funding. A solid grounding in basic mathematical, scientific, and cultural concepts facilitates the adjustment to more specialized training.

At present, however, support for post-secondary education is largely in the form of loans for college, with a scattered assortment of programs for "retraining." Typically, this training is available only after a person has lost a job. The pain of adjustment could be significantly reduced if training were conducted before calamity strikes. Advanced warning of layoffs would clearly help.[32]

Subsidies for training beyond high school could be available throughout a person's career, and not be limited to formal university curricula. A combination of entitlements and loan subsidies could allow flexibility in the timing and location of post-secondary education. The entitlements might cover the equivalent of 2 years of college tuition, with some further amount of training receivable at any point in an individual's career. With appropriate safeguards, such programs could also be used to support in-house corporate training programs. Loans could be repaid automatically through payroll deductions when the person is working, but would not exceed an acceptable percentage of gross income—6 percent might be such a level.

Universal National Service.—A program requiring all young Americans—possibly between the ages of 18 and 26—to undertake some kind of public service for 1 or 2 years could have a variety of benefits. Joining the armed services would be one of several options; teaching assignments might be more appropriate for college graduates, and such work could also help reduce the cost of publicly supported education. If entry into a service program could be adjusted to coincide with periods of excessive unemployment, it might provide a useful tool to smooth large fluctuations in unemployment rates.

One of the dangers inherent in the highly fragmented, market-oriented future suggested earlier is that citizens will fail to recognize their obligations to the society that supports them. This program would give participants an opportunity to acquire that sense of responsibility, and to view aspects of American life that they would otherwise never experience first-hand.

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[32] For more on this subject, see *Technology and Structural Unemployment—Reemploying Displaced Adults*, op. cit., footnote 24; and U.S. Congress, Office of Technology Assessment, *Plant Closing: Advance Notice and Rapid Response*, OTA-ITE-321 (Washington, DC: U.S. Government Printing Office, September 1986).

Encouraging Commitment to Employees Through Greater Use of Bonuses and Profit-Sharing.—Employers can be encouraged to achieve flexibility through compensation adjustments instead of layoffs, tying private bonus payments to changes in a business' value-added or using bonus payments for the government payrolls that comprise nearly 20 percent of the total work force (see discussion in ch. 11). Bonuses allow a company to adjust its payroll costs during difficult times in a transparent way without the need to renegotiate all wages.[33]

It is possible that if enough firms adopted a policy where wages represented a fixed base with bonuses dependent on a firm's performance, the U.S. economy could more efficiently respond to problems encountered during economic downturns. There has already been considerable movement in this direction: apart from small business, 19 percent of all production employees, 27 percent of all technical and clerical employees, and 23 percent of all professional and administrative employees were covered by some kind of profit sharing agreement in 1983.[34] One way of encouraging such programs might be to lower the taxes paid on bonuses.

Universally Retainable Pensions and Health Insurance.—Even with a significant change in compensation plans, it is likely that structural change in the U.S. economy will result in a continuous series of new business starts and failures. Labor mobility will be essential to ensure that the system adjusts efficiently to new opportunities. It is not reasonable to expect individuals to bear the full cost of the adjustment. Apart from retraining and unemployment support, it is important that people forced to shift jobs be able to maintain pensions and health insurance.[35]

Currently, it is difficult to hold onto a pension while changing jobs. In 1986, 80 to 90 percent of all pension plans required workers to remain with a firm for ten years before being "vested" (receiving rights to a pension). A 1981 survey found that only 2 percent of all employees covered by single-employer corporate pension plans were able to transfer vested pension credits to another plan; evidence suggests that this ratio has not changed significantly since that time.[36] People forced to take a series of part-time or temporary jobs can expect to have no pension coverage. Correcting the problem may be critical for developing a consensus about the need for mobility within America's labor force.

Many workers also risk losing their pensions if their companies file for bankruptcy. Nearly 30 million Americans—the vast majority of those with "defined benefit" plans—are now covered by the Pension Benefit Guarantee Corp. (PBGC). The fund, however, is in grave trouble as the result of bankruptcies in firms with large, underfunded pension programs. Many are in the steel industry; the LTV Corp.'s failure alone threatened to exceed the PBGC's assets.[37] In addition, another 10 million workers are under "defined contribution" pension plans not covered by the PBGC.

Similarly, health insurance plans vary enormously around the Nation, making continuity very difficult. Many small firms offer limited coverage or none at all. Small firms pay much more than large ones to cover each employee, while health insurance costs for people who are not members of an organization qualifying for group insurance rates are higher still. Bankruptcy can threaten any coverage. Recent law has alleviated some, but far from all problems in this area.

Given that the economy as a whole benefits from labor mobility, it is reasonable to expect that companies, and society as a whole, should pick up some of the cost of this flexibility. Programs that ensure the continuity of pensions and health insurance could be improved. The displaced should not have to bear the entire cost. The government may not save money by ignoring the problem, since costs clearly increase when welfare cases grow in number, or when Medicaid is forced to cover the cost of serious illnesses that may develop because people without health insurance postpone medical treatment.

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[33] M.L. Weitzman, *The Share Economy* (Cambridge MA: Harvard University Press, 1984).

[34] R.M. Kanter, "The Attack on Pay," *Harvard Business Review*, vol. 65, No. 2, March-April 1987, p. 61.

[35] See P. Choate and J.K. Linger, *High-Flex Society: Shaping America's Economic Future* (New York, NY: Knopf, 1986).

[36] Ray Schmitt, "Pension Vesting, Integration, and Portability (VIP)," U.S. Congressional Research Service, report No. 85-884-EPW, Washington, DC, Aug. 9, 1985.

[37] The PBGC has recently ruled that LTV's pension liability must be handled by that company. See Cindy Skrzycki, "Agency Returns Pension Liabilities to LTV," *The Washington Post*, Sept. 24, 1987, p. D1.

Encouraging Greater Flexibility of Working Hours (under mutual agreement between employers and employees).—New information technologies make it possible to manage varying work schedules more easily than ever before. They even permit taking some work home, since much work in the U.S. economy now involves manipulation of information and not things. Greater flexibility in work time would not only make it easier for parents to combine work with child raising, it would make it easier for people to combine vocations with avocations and even to make better use of public highways and recreational facilities.[38]

Workers are understandably reluctant to allow employers the freedom to change work schedules, while employers are understandably reluctant to allow employees flexibility that might interfere with production schedules. Surely some compromise is possible. Initial steps might include:

- Encouraging the implementation of State, local, and private sector programs similar to the Federal Employees' Flexible and Compressed Work Schedules Act (first passed in 1978 and made permanent in 1985), which allows Federal government workers to adopt a schedule of either 8-hour days at odd hours or longer but fewer days. The success of this program, in which the employer and employee must both agree on the "flex-time" arrangement, has been documented by the positive response it receives from most of the nearly 500,000 employees involved, and by the higher productivity it appears to foster.[39]
- Second, the statutory restrictions on experiments with flexible work schedules of over 40 hours in a single week, like the Fair Labor Standards Act, which covers roughly two-thirds of the U.S. work force; and the Contract Work Hours and Safety Standards Act, which applies to all workers under contract to the Federal Government, might be reexamined.[40]

Subsidies for Child Care.—Children may too often be victims in the U.S. economy. Parents, particularly those with low incomes, are frequently forced to place their children in inadequate child-care facilities or leave them unattended at home as "latch key" children. Greater flexibility in labor markets, and better early education for children, would result from accepting some portion of child care as a public responsibility—day care programs now in place in various Federal agencies could serve as models for such an approach.

At some extra expense, schools that are closed during the summer could shift to year-round training, as they do in Japan and Taiwan. This would also alleviate the dilemma many teachers face in finding temporary employment during the summer. During the academic year, the functions of school facilities could be expanded so that children would be routinely kept in supervised activities unless parents wanted them home immediately after school.

Linking Welfare Programs to Reemployment Strategies.—Some welfare programs may have the effect of reducing incentives for individuals to rejoin the work force, or may even act to weaken family structures. Retraining, subsidized day care for working parents, and other programs designed to encourage reemployment need to be better integrated with welfare initiatives. Some interesting models for this exist at the State level, notably in Pennsylvania and Massachusetts.[41]

Providing Consistent Protection for Workers.—An economy built around flexible production networks, comparatively small firms or establishments, and an assumption of continuous change in production methods and products can undermine standard methods for protecting workers from harmful exposure to chemicals and other health risks. Many production methods are replaced even before the safety of a new process is completely understood. New technologies also introduce a range of health and safety issues unlike the more obvious risks of work in physically dangerous occupations. Management of stress, indoor air quality, and other factors becomes increasingly critical. Electronic supervision of employees not only increases stress but can raise serious questions of privacy.[42]

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[38] See John D. Owen, *Working Hours* (Lexington, MA: Lexington Press, 1979).

[39] U.S. Congress, General Accounting Office, "Alternative Work Schedules for Federal Employees," GAO/GGD-85-63, Washington, DC, July 19, 1985.

[40] Legislation guiding standards for Federal contract workers is broken down by type (named for sponsors of each act): Walsh-Healy for suppliers of goods, Davis-Bacon for suppliers of construction, and McNamara-O'Hara for suppliers of services.

[41] See Todd W. Rufuth, "Moving Clients Into Jobs," *Public Welfare*, spring 1987, pp. 10-21.

New technologies and the changing occupational structure of the work force alter the nature of health and safety problems, while changes in the scale and scope of businesses affect opportunities for solving the problems. A basic review of priorities in the area may be needed.

Improving the National Database

It is essential that policy be built on the best possible information. While data collection is an unromantic subject, severe flaws in national statistics present barriers to clear thinking about both domestic and international policy (the list could be continued at much greater length):

- data linking consumer spending to household types are extremely limited;
- data on living conditions of the poor (i.e., how many are homeless, how many are hungry, how many lack health care) are largely speculative, and differ widely depending on the source being used;
- detailed benchmark input/output data, specifying what inputs are used by U.S. industries to produce the Nation's output—of critical importance to national accounts—are typically as much as 10 years old;
- input/output accounts lack information about the role of imports critical for important classes of analysis;
- data on service industries are far less detailed than data on manufacturing;
- information about programs affecting trade by directly or indirectly promoting exports or discouraging imports is scattered throughout both the Federal Government and independent agencies like the International Trade Commission, and has not been assembled in a form useful for integrative analysis;
- information on inputs and employment in government is extremely limited;
- information on research and training in private and public firms is virtually nonexistent;
- different sets of government accounts track data in different ways and use a bewildering variety of categories, which often means that comparisons between the National Income and Product Accounts, input/output statistics, industry data from the Bureau of Labor Statistics, and trade statistics are incompatible; and
- accounts of government receipts and spending are maintained as unrelated entities, making it difficult to understand changes in net Federal commitments (such as commitments from pensions), in net subsidies (from guaranteed or subsidized loans or tax benefits), or in the overall value of Federal assets.

Perhaps most importantly, the basic structure of American economic statistics makes all government spending appear as current consumption—in effect, government investment is not allowed to appear as such. This can be dangerously misleading.[43] There are few investments that are more important to the future than when government taxes individuals for such collective purchases as education, roads and other national infrastructure, and basic research.

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[42] U.S. Congress, Office of Technology Assessment, *The Electronic Supervisor: New Technology, New Tensions*, OTA-CIT-333 (Washington, DC: U.S. Government Printing Office, September 1987).

[43] See R. Eisner, op. cit., footnote 17.

YOU CAN'T GO HOME AGAIN

The present chapter, and indeed this entire document, presents the future of the American economy in terms of a series of choices—choices that must be made by people acting as consumers, as investors, as employees, and as voters. New information technology, and an economy irrevocably enmeshed in international trade, have done far more than make old choices about the pursuit of happiness more complex. They have forced consideration of an unprecedented new range of choices.

Many of the paradigms that once described expectations about the American economy no longer apply. For example, it may once have been reasonable to expect that:

- the American economy could be managed without continuous concern for foreign economies,
- most significant technical innovations would be developed and used first by Americans,
- hands-on production jobs would dominate attractive employment opportunities,
- large "economy of scale" production facilities capable of driving down the price of mass produced commodities would dominate production, and
- a person with a conventional high-school education could earn an income adequate to support a middle-class family.

However desirable or undesirable, none of these are realistic descriptions of America's future. Instead, it is not only possible, but likely, that networks delivering amenities ranging from housing to education will be transformed in fundamental ways over the next generation. None of the alternatives are familiar ones.

A particularly dramatic change is likely in the mix of marketable skills. These skills are likely to differ significantly from those that dominated the work force of the 1960s. Demand for manual skills will decline and demand for intellectual skills, and skill in working with people will increase. Specifically, a person's success in the new environment is likely to depend critically on the extent to which the nation's educational system gives them basic skills and the ability (and opportunity) to upgrade knowledge and skills continuously. The key publicly-supported infrastructure in such a world may well be a productive system for teaching and learning.

The preceding pages have attempted to describe important characteristics of the practical options now available and the policy strategies likely to shape the direction taken. History may well prove wrong many of the details.

In the face of great uncertainty, two things seem clear:

1. The possibilities open to America in 1988 represent a set of stark contrasts. A society could be built that vastly increases the power of all Americans to express unique tastes, and find work that both pays well and is rewarding in other ways. But one could also be built that rewards only an elite while a majority of Americans are constrained to live with shrinking opportunities. While a highly linked world economy could increase prosperity throughout the globe, tension over trade could undermine longstanding friendships and the very foundations on which Western security has been based for a generation.
2. Secondly, the difference between the alternatives depends as never before on choice instead of necessity. These choices, in turn, hinge crucially on the management of public policy. This requires finding ways both to expand the economy in ways that create attractive employment opportunities and provide Americans with the training needed to take advantage of these opportunities.

It is inevitable that America's system for connecting human talent, dedication, and sacrifice to the production of amenity will be transformed during the next few decades. Choices made today play a crucial role in determining which of many possibilities becomes our legacy.

Appendix

Appendix on Data and Methods

Input-Output Analysis

Much of the analysis that appears in chapters 4, 5, 7, and 10 is based on input-output calculations. The following discussion will briefly review input-output methods, focusing on techniques employed in this study that may be unfamiliar. For a comprehensive treatment of the theory behind input-output analysis see the recent text by Miller and Blair.[1] A description of the mechanics involved in constructing input-output tables and the underlying mathematical derivation are contained in a report published by the Department of Commerce.[2]

The analysis actually employed in the input-output calculations presented in this report used 85 business sectors. Detail is available on 537 business types for the "benchmark" years in which the quinquennial census of industries is conducted.[3] Unfortunately the last "benchmark" for which data are available is 1977. The Department of Commerce has updated the 85-sector data to 1981 using annual survey data that are much less comprehensive than the census data.[4]

The "Use" Table

The heart of input-output data is the "use" table. The columns of this table show the value of each commodity *used* in a given year by producers in each type of industry.[5] Matrix element U(i,j) shows the value of commodity i used by industry j for i and j = i to 85. Data are also provided on the total value of industry and commodity output and the value-added by each industry.

The 1977 table shows, for example, that the motor vehicles and equipment manufacturing industry (j = 59) produced output whose total value was $117.7 billion. This output was created by purchasing $84 billion in comodities from other businesses, and adding $33.7 billion in value in industry 59 itself. The columns of the use table indicate the amounts of each type of comodity purchased by the industry. For example, in 1977 the motor vehicle industry purchased $2.3 billion worth of miscellaneous fabricated textile products (i = 19), and $5.0 billion of rubber and miscellaneous plastic products (i = 32).

The use of different commodities by the various industries can be expressed as a series of linear equations using the following variable names: call the total value of the output of industry j, X(j), and the value-added by industry j, VA(j).[6] The fact that the value of industry output is equal to the value of commodities purchased as inputs plus the value-added by the industry can be written as follows:

$$X(j) \quad = \quad \sum_{i=1}^{85} U(i,j) \quad + \quad VA(j) \qquad (1)$$

The total output for a particular commodity in the economy is equal to the sum of the deliveries of a commodity to all industries in the economy plus any deliveries to final demand. Hence, if Y(i) is defined to be the sales for commodity i, and Q(i) the total output of commodity i in the economy, we can write this accounting equation in the following form:

$$Q(i) \quad = \quad \sum_{j=1}^{79} U(i,j) \quad + \quad Y(i) \qquad (2)$$

The sum extends only from j = 1 to 79 since at the 85-sector level, only the first 79 industries use intermediate inputs from domestic industries. The remaining 6 industries are: Noncomparable imports [j = 80], Scrap, Used, and secondhand goods [j = 81], Government Industry [j = 82], Rest of the world industry [j = 83], Household industry [j = 84], and Inventory valuation adjustment [j = 85]. All elements of U(i,j) are zero for i = 82 to 85 and for j = 80 to 85.

Final Demand (Y(i)) is divided into five components[7]:

$$Y(i) = C(i) + GPFI(i) + INV(i) + EXP(i) - IMP(i) \qquad (3)$$

where

C(i) = commodity i purchased as final demand by consumers and the government
GPFI(i) = commodity i purchased as gross private fixed investment
INV(i) = inventory change in commodity i
EXP(i) = exports of commodity i
IMP(i) = imports of commodity i

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[1] Ronald E. Miller and Peter D. Blair, *Input-Output Analysis* (Englewood Cliffs, NJ: Prentice-Hall), 1985. For further reading, see Wassily Leontief, *Input-Output Economics* (New York, NY: Oxford Press, 1966); and Alpha C. Chaing, *Fundamental Methods of Mathematical Economics* (New York, NY: McGraw-Hill, 1974).

[2] Philip M. Ritz, "Definitions and Conventions of the 1972 Input-Output Study," Department of Commerce, Bureau of Economic Analysis, Staff Paper, BEA-SP 80-034, July 1980.

[3] See for example, U.S. Department of Commerce, Bureau of Economic Analysis, *The Detailed Input-Output Structure of the U.S. Economy, 1977*, 1984.

[4] Mark A. Planting, "Input-Output Accounts of the U.S. Economy, 1981," *Survey of Current Business*, January 1987. The 1980 revision was the latest available for most of the calculations presented in the text.

[5] The use table is shown as table 1 in the "Input-Output Structure of the U.S. Economy, 1977," U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, vol. 64, No. 5, May 1984, p. 52.

[6] The following calculations will use a notation that differs from standard input/output notation. The object of the present discussion is to provide a clear, and quick description of the analysis for the lay reader. The variable names were chosen as mnemonics in order to obviate memorizing numerous unfamiliar variables that will only be used once. Standard notation will be indicated in the notes. For example, most works use W to represent value-added.

[7] In conventional notation: C = commodity purchased as final demand by consumers, G = commodity purchased as final demand by the government, J = commodity purchased as gross private fixed investment, N = inventory change in commodity, E = exports of commodity, M = imports of commodity.

For simplicity, the effects of inventory change are not included in the following discussion and the variable INV is not used.[8]

The "Make" Table

Calculations are complicated by the fact that some commodities are made by more than one industry. In 1977, for example, only \$50.7 billion of the \$63.2 billion worth of Chemicals and selected chemical products (commodity #27) were made by the Chemicals and selected products industries (industry #27) the remainder being produced by other industries. Petroleum refining and related industries produced \$6.9 billion worth of commodity #27.

In input-output analysis, the table used to account for secondary production in an economy is called a "make" table written in matrix form as M(i,j).[9] The columns of the make show the commodities j produced by industry i. The diagonal elements of the table show the primary products of industries, while the off-diagonal elements are the secondary products. The make matrix includes all commodity output (including deliveries to final demand), and all industry output. These accounting relationships can be written as follows:

$$Q(j) = \sum_{i=1}^{85} M(i,j)$$

The make table is created by collecting data on individual establishments within an industry category. The output of each establishment is assigned to a single commodity class. In practice, of course, many establishments make more than one product (sometimes referred to as secondary production). The output of each establishment is assigned to the commodity type representing the largest fraction of its output. Most establishments producing more than one commodity produce items that all fall into only one of 85 possible commodity classifications. As firms expand the scope of their production, however, this may be an increasingly tenuous assumption (see ch. 5).

Correcting for Scrap

By convention, each industry is permitted to make "scrap" in addition to other commodities. Call the amount of scrap produced by industry S(i). The total output of an industry can then be written as the sum of commodities 1 to 79 it produces plus scrap. The equation is as follows:

$$X(i) = \sum_{j=1}^{79} M(i,j) + S(i) \qquad (4)$$

The available data can be used to calculate the fraction of all industrial output produced as scrap [S(i)/X(i)] and the fraction of commodity i produced by industry j [M(i,j)/Q(j)].[10] As a result, equation (4) can be rewritten as follows:

$$X(i) = [1/(1\text{-}S'(i)] * \sum_{j=1}^{79} [M(i,j)/Q(j)] \cdot Q(j) \qquad (5)$$

Where $S'(i) = S(i)/X(i)$.

Shifting to vector notation, let **X** be a 79-element vector representing industry output, **Q** be a 79-element vector representing commodity output, **Y** be a 79-element vector representing the first 79 elements of final demand.[11] The 79x79 matrices **U**′ and **M**′ are defined as follows in their normalized form:[12]

$$U'(i,j) = U(i,j)/X(j) \qquad (6)$$

$$M'(i,j) = [1/(1\text{-}S'(i))]*[M(i,j)/Q(j)] \qquad (7)$$

Notice that these equations make two major assumptions that lie at the core of input-output calculations and make it mathematically possible to describe the behavior of a highly linked economy:

I. *Industry inputs change in direct proportion to industry output.*

II. *The fraction of a commodity produced by each industry (including the fraction of output counted as scrap) remains fixed.*

Equation (4) can be rewritten in the new notation to provide a convenient bridge between industry output and commodity output:

$$\mathbf{X} = \mathbf{M}'*\mathbf{Q} \qquad (8)$$

The normalized matrices **U**′ and **M**′ can be used to rewrite equation (2) as follows:

$$\mathbf{Q} = \mathbf{U}'*\mathbf{X} + \mathbf{Y}$$

$$\mathbf{Q} = \mathbf{U}'*\mathbf{M}'*\mathbf{Q} + \mathbf{Y}$$

or

$$\mathbf{Q} = \mathbf{A}*\mathbf{Q} + \mathbf{Y} \qquad (9)$$

Where $\mathbf{A} = \mathbf{U}'*\mathbf{M}'$ is Leontief's original "transactions" matrix whose jth column shows the value of a commodity needed to make a dollar's worth of commodity output. The **A** matrix was shown in summary form in table 4-2.

Constructing the Basic Equation

Equation (9), the key equation of input-output analysis, is equivalent to 79 coupled linear equations. It's solution allows an estimate of the total output of a commodity (or industry) created by any pattern of final demand. Making the key assumptions of linearity described earlier, a solution to (9) can be written as follows:

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[8] For most purposes, changes in inventories can be treated exactly as changes in C.

[9] The "make" table is shown in table 2 in the article cited in footnote 1.

[10] The scrap produced by each industry is shown in columns #81 of the Make table—Table 2 in the Department of Commerce publication cited in footnote 1.

[11] In this discussion vectors and matrices are represented in **BOLD** type. Matrix multiplication is indicated using the character * also used to indicate scalar multiplication (i.e. the product of two vectors **G** and **H** could be written as the sum over i of G(i)*H(i) or as **G*H**.)

[12] In conventional notation U' is called B (the matrix of "technical coefficients") and M' is called D (the matrix of "commodity output proportions").

$$\mathbf{Q} = (\mathbf{I}\text{-}\mathbf{A})^{-1} * \mathbf{Y} \tag{10}$$

Industry output can be calculated using equation (8) to convert commodity output to industry output:

$$\mathbf{X} = \mathbf{M}' * (\mathbf{I}\text{-}\mathbf{A})^{-1} * \mathbf{Y} \tag{11}$$

Including Capital Goods in the Transactions Table

The matrix **U** used in the construction of equation (6) does not include any purchases of capital equipment. Capital equipment purchases are included as a part of final demand (see equation (3)). Ultimately, of course, the purchase of capital goods depends on the size and growth rates of different types of industries. A fully dynamic model can include these effects.[13] It is possible, however, to make a third simplifying assumption and include annual capital purchases of each industry as a part of an expanded transactions table. The assumption is:

> *III. Industry purchases of gross private fixed investment are in direct proportion to industry output.*

This assumption can be put to use given the gross private fixed investment in commodity type i purchased by industry j. Call this matrix CAPITAL(i,j). Data for CAPITAL(i,j) are available for the input-output benchmark years.[14] Call this benchmark matrix $\text{CAPITAL}_b(i,j)$. The data, available for the benchmark years, can be updated given information about gross private fixed investment by commodity (GPFI(i)) in any given year. One component of GPFI, residential structures, is not incorporated into the transactions table because it is not an input into a businesses production process. This updating procedure makes the assumption that the share of a particular capital good used by the various industries has not changed from the benchmark year used and it makes no effort to distinguish between capital purchased for replacement and capital used for expansion.

The matrix $\text{CAPITAL}_b(i,j)$ can then be used to create a new transactions matrix **A**″ that includes intermediate inputs and gross private fixed investments. The matrix **A**″ can be defined as follows:

$$A''(i,j) = A(i,j) + [\text{CAPITAL}_b(i,j)/X(j)] * [\text{GPFI}(i)/(\sum_{k=1}^{79} \text{CAPITAL}_b(i,k))]$$

It should be noted that capital coefficients tend to be much less stable than the technical coefficients. Equation (9) can then be rewritten as follows:

$$\mathbf{Q} = (\mathbf{I}\text{-}\mathbf{A}'')^{-1} * (\mathbf{C} + \mathbf{EXP} - \mathbf{IMP}) \tag{12}$$

Where domestic final demand, inventory changes, exports, and imports have been written as 79-element vectors.

Adjusting for the Effects of Trade

The use table appearing in equation (1) shows the commodities needed as inputs to an industry's production process without regard to whether they were produced by a domestic industry or purchased from abroad. Similarly, no distinction is made between the consumer or government purchases of foreign and domestic products. Unfortunately no data is available to distinguish between foreign and domestic products in either the use table or in consumer and government purchases. It is possible to explore situations where imports have penetrated different proportions of U.S. markets by making a fourth simplifying assumption:

> *IV. The fraction of a given commodity supplied by imports is the same for each industry. The fraction also represents the imported proportion of all consumer and government purchases.*

Let the fraction of a commodity i supplied by domestic producers (eg. the fraction imported) be called R(i). These ratios can be computed from equation (9) imports of commodity i used as intermediate demand and imports of commodity i purchased by consumers and by the government must combine to total total imports IMP(i). Using the notation of equation (9),

$$\text{IMP}(i) = \sum_{j=1}^{79} A''(i,j) * Q(j) * R(i) + C(i) * R(i) \tag{13}$$

rearranging:

$$R(i) = \text{IMP}(i)/[\sum_{j=1}^{79} A''(i,j) * Q(j) + C(i)] \tag{14}$$

This ratio can now be used to remove imports from equation (11).[15] The resulting equations effectively treat all imports as noncomparable imports which are not included in transactions. The domestic part of the transactions matrix can be written as $\mathbf{A}''_d$, and the domestic part of final consumer and government consumption as C_d defined as follows:

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[13] See Wassily Leontief and Faye Duchin, *The Impacts of Automation on Employment: 1963—2000*, Institute for Economic Analysis, under contract to the National Science Foundation, Contract #PRA-8012844, April 1984, for an example of a dynamic model.

[14] Gerald Silverstein, "New Structures and Equipment by Using Industry, 1977," *Survey of Current Business*, November 1985; and Peter B. Coughlin, "New Structures and Equipment by Using Industry, 1972," *Survey of Current Business*, July 1980.

[15] For other analyses that use this trade adjustment method see Kan Young, Ann Lawson, and Jennifer Duncan, "Trade Ripples Across U.S. Industries," Working Paper, U.S. Department of Commerce, Office of Businesss Analysis, January 1986; and Charles F. Stone and Isabel Sawhill, "Labor Market Implication of the Growing Internationalization of the U.S. Economy," paper for the National Commission for Employment Policy, Contract #J-9-M-5-0040, February 1986.

$$A''_d(i,j) = (1\text{-}R(i))*A''(i,j) \qquad (15)$$

$$C_d(i) = (1\text{-}R(i))*C(i) \qquad (16)$$

Using equations (14) through (16) in (1) an equation can be written that includes only domestic inputs and the part of consumer and government demand met from domestic producers:

$$\mathbf{Q} = (\mathbf{I}\text{-}\mathbf{A}''_d)^{-1} * (\mathbf{C}_d + \mathbf{EXP}) \qquad (17)$$

$$\mathbf{X} = \mathbf{M}'*(\mathbf{I}\text{-}\mathbf{A}''_d)^{-1} * (\mathbf{C}_d + \mathbf{EXP})$$

Equation (8) has again been used to convert commodities Q to industry output X.

Equation (17) can now be used to explore the effects of different patterns of trade. For example the calculations presented in chapter 7 were computed using the following techniques:

- An economy with no imports can be constructed by holding EXP(i) constant and setting R(i)=0 for all i.
- An economy with no exports can be constructed by holding R(i) constant and setting EXP(i)=0 for all i.
- An economy with no trade can be constructed by setting R(i)=EXP(i)=0 for all i.

Notice that the total amount of domestic production is different in each case.

When an attempt is made to show what would happen if, for example, 1984 trading patterns applied in 1972, ratios similar to R(i) can be computed for both imports and exports and used to construct an equation similar to (14) except that only consumer and government purchases remain as final demand. This was done in the calculations of chapter 5. The impact of changes in final demand on industry output **X** could be computed by altering **C**, changes in producer recipes could be considered by changing **A''**, and changes in trade by changing R(i) (and an equivalent set of ratios for exports).

One final complication must be introduced. Using standard BEA conventions, tariffs levied against imports are counted as a part of the imports of wholesale and retail trade (i=69) and transportation and warehousing (i=65), resulting in a postive import figure for those two commodities. Imports are normally reported as a negative component of final demand. In most cases the ratios R(i) for these two commodities are not set to 0 when a "no import" cases are considered, eliminating any effect caused by changing levels of duties on value-added or jobs.

The ratios calculated for the case when the transactions matrix is adjusted for both imports and exports, are shown in table A-1 for the years 1972, 1977, 1980, and 1984.

Adjusting for Inflation

As the discussion of chapters 4 and 5 point out, an analysis of structural change which is not sensetive to price effects requires a way to convert equations like (17) into

Table A-1.—Import and Export Penetration of Domestic Consumption (R(i))

I-0 industry number	1972	1977	1980	1984
1	0.99638	0.99668	0.99732	0.99711
2	1.13763	1.22197	1.36148	1.35224
3	0.68196	0.82617	0.85170	0.61239
4	1.00411	1.00238	1.00357	1.00264
5	0.71468	0.72308	0.97932	0.93621
6	0.85251	0.85694	0.81841	0.80827
7	1.10012	1.13734	1.17189	1.17266
8	0.85830	0.55526	0.64179	0.73057
9	0.97033	0.97905	1.00394	1.01465
10	0.96660	0.99811	0.99023	0.88700
11	1.00008	1.00000	1.00002	1.00000
12	1.00016	1.00035	1.00032	1.00035
13	1.03645	1.19322	1.12094	1.08519
14	0.98373	0.99458	0.99783	0.99123
15	1.09075	1.12184	1.13420	1.05530
16	0.97380	1.00279	1.02382	0.94681
17	0.93414	0.99347	1.03886	0.94244
18	0.92693	0.88988	0.87163	0.76981
19	0.99465	1.00835	1.01180	0.95152
20	0.94652	0.95999	0.99217	0.94942
21	0.99782	0.94497	0.95938	0.98778
22	0.97538	0.97392	0.97693	0.96688
23	0.97440	0.97317	0.95769	0.89611
24	0.95912	0.95990	0.97810	0.95551
25	1.00341	1.01286	1.00956	1.00468
26	1.00815	1.01085	1.01345	1.02135
27	1.03750	1.03102	1.05875	1.07061
28	1.04874	1.05883	1.12547	1.08509
29	1.02309	1.01285	1.00386	1.02106
30	1.01916	1.02558	1.02828	1.01920
31	0.93417	0.91723	0.93132	0.91806
32	0.97348	0.97559	0.98605	0.96655
33	0.92430	0.99445	1.03125	0.93547
34	0.81517	0.72191	0.68944	0.49741
35	0.97748	1.00395	1.01164	0.95776
36	0.97576	0.97548	0.97220	0.95647
37	0.92915	0.91808	0.93415	0.88598
38	0.92932	0.92639	0.97582	0.85358
39	1.00210	1.00277	1.00909	0.99759
40	1.01587	1.03349	1.03204	1.01474
41	1.02922	1.02255	1.02332	1.01848
42	0.98350	0.98984	0.98410	0.95595
43	1.08907	1.16325	1.13442	1.04763
44	1.00256	1.01627	0.99853	0.99282
45	1.30584	1.26968	1.39385	1.21651
46	1.02528	1.04767	1.05790	0.97490
47	1.03972	1.00981	0.98710	0.95082
48	1.04678	1.14341	1.09642	0.92172
49	1.04430	1.07955	1.05441	0.98087
50	1.01635	1.00774	1.01349	1.04215
51	1.12892	1.13879	1.20961	1.03667
52	1.05915	1.09862	1.12053	1.05859
53	1.02810	1.03293	1.09864	1.04475
54	0.95881	0.97119	0.99456	0.93552
55	1.01201	1.02757	0.96785	0.98016
56	0.91533	0.89801	0.93408	0.81497
57	1.05319	1.01658	1.01127	0.88130
58	0.99511	1.01121	1.00079	0.98615
59	0.93747	0.94131	0.87614	0.80553
60	1.17626	1.34053	1.27526	1.15410
61	0.92683	0.98572	0.97620	0.96223

Table A-1.—Import and Export Penetration of Domestic Consumption (R(i))—(Continued)

I-0 industry number	1972	1977	1980	1984
62	1.04763	1.04451	1.02127	1.01192
63	1.00619	0.98295	1.00607	0.93225
64	0.91194	0.88240	0.86642	0.73565
65	1.05597	1.07930	1.08638	1.08062
66	1.01285	1.01899	1.02057	1.02866
67	1.00000	1.00000	1.00000	1.00000
68	0.99565	0.98453	0.97851	0.98173
69	1.03358	1.04830	1.06149	1.05060
70	1.00116	1.00083	1.00149	1.00157
71	1.01177	1.01345	1.01468	1.01489
72	1.00013	1.00062	1.00061	1.00096
73	1.00949	1.02132	1.01796	1.02743
74	1.00000	1.00092	1.00083	1.00157
75	1.00000	0.99979	0.99981	0.99972
76	1.03465	1.01681	1.02182	1.02022
77	1.00027	1.00046	1.00034	1.00049
78	1.01485	1.01375	1.00385	1.01553
79	1.00000	1.00010	1.00014	1.00016
80	0.00000	0.00002	0.00000	−0.78546
81	0.87134	2.35374	−3.12859	0.89780
82	1.00000	1.00000	1.00000	1.00000
83	−1.85569	−3.11294	−4.06765	−1.80829
84	1.00000	1.00000	1.00000	1.00000
85	1.00000	1.00000	1.00000	1.00000

constant dollars.[16] Most of the data used in this analysis are expressed in 1980 dollars because of the extensive use of the 1980 input-output table as an endpoint. The calculation of constant dollar industry output or value-added can be done by defining C80(i) to be the consumer and government demand for product i expressed in constant 1980 dollars, and U80(i,j) to be the use matrix in constant dollars. They can be computed as follows:

$$C80(i) = P(i)*C80(i)$$
$$U80(i,j) = U(i,j) * P(i)$$

Using the definition in equation (6):

$$U80'(i,j) = U80(i,j)/X80(j) = U'(i,j)*P(i)/P(j) \quad (18)$$

Assuming that the deflator for an industry's scrap is the same as the deflator for the entire industry the matrix M′ is unaffected by the deflation process since it involves ratios of identical commodities. As a result, a 1980 based A matrix can be calculated as follows:

$$\mathbf{A}80(i,j) = \mathbf{A}80'* M'$$
$$A80(i,j) = A(i,j)*P(i)/P(j) \quad (19)$$

Equation (18) can also be used to compute a deflated value-added using equation (1)[17].

$$VA(j) = X(j) - \sum_{i=1}^{85} U(i,j)$$

$$VA80(j) = X(j)*P(j) - \sum_{i=1}^{85} U(i,j)*P(i) \quad (20)$$

Equation (20) provides a way to construct a deflated value for value-added given deflators for the products of each industry. Because it involves deflating both the gross output, X(j), and the intermediate inputs, U(i,j), it is called "double-defaltion." The process is considered a "preferred method" when all relevant data is available.[18] As the discussion of chapter 5 points out, however, it is often necessary to use other methods to compute deflators for value-added. Arguments about the ratio of deflated manufacturing value-added to the sum of all value-added in the economy (the GNP) hinge on disputes about the validity of these alternative methods.

While the logic of the deflation process just described may be clear, two problems must be overcome to put it to practical use. The first problem results from the fact that deflators for the 85-level input-output industries are not published as a consistent time series. The Bureau of Labor Statistics compiles such a series, but the deflators are for 156 industries and are based on gross output (the value of shipments).[19] Using them in equations 18-20 requires an aggregation for some to the 85 BEA input-output industries using current dollar value of their gross output.[20]

A second problem results from using domestic price deflators to adjust input-output tables when many intermediate inputs are imported. The Producer Price Index that forms the basis for industry deflators is based on

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[16] For additional examples of deflating input-output matrices, see Wassily Leontief and Faye Duchin, *The Impacts of Automation on Employment: 1963—2000*, op. cit., p. 3.18; and Anne P. Carter, *Structural Change in the American Economy* (Boston, MA: Harvard Univeristy Press, 1970), p. 21.

[17] Equation (20) makes the implicit assumption that deflators for industry and deflators for commodities are identical. For simplicity, this assumption is frequently used in practice. The error introduced by using industry deflators for commodities can be estimated by using the make matrix to convert commodity deflators to industry deflators. If the industry deflator is called P′ The deflator for industries 1-79 are computed as follows:

$$P'(j) = \sum_{k=1}^{79} M(j,k)*P(k) \;/\; \sum_{k=1}^{79} M(j,k)$$

The procedure reveals that errors of were close to 3 percent in only 4 of 85 industries—most prove to be very small. Attempting to use the make matrix to compute commodity deflators from industry deflators and vice versa introduces an additional uncertainty because the make matrix is only updated infrequently. As a result, estimation of P′ contains errors whose size is difficult to estimate except when benchmark years are compared.

[18] Milo F. Peterson, "Gross Product by Industry, 1986," *Survey of Current Business*, April 1987, pp. 25-27.

[19] See Valerie A. Personick, *Methodology for Time Series Data on Industry, Output, Price and Employment*, unpublished Bulletin, Bureau of Labor Statistics, Office of Economic Growth and Employment Projections, fall 1987; and "Time Series Data Base for Input-Output Industries," unpublished, Bureau of Labor Statistics, Office of Economic Growth and Employment Projections, June 1985.

[20] See "BLS Economic Growth Model System Used for Projections to 1990," Bulletin 2112, April 1983, app. F.

changes in domestic prices.[21] Using domestic deflators obviously leads to an error under conditions of disequilibrium when the price of foreign goods may be changing at different rates than the price of domestic goods. The error can be reduced by removing imported products from the transactions table using methods described in equations 13-16.

Converting Industry Output to an Estimate of Employment

Equation (13) allows an estimate of output given assumptions about demand (**Y**), producer recipes (**A**), and trade (R(i), and EXP(i)). The estimates of output **X** can be converted to estimates of employment for each industry and occupation through use of a matrix which shows the number of jobs in occupation category k available in industry i. Call this matrix L(k,i). The number of jobs in occupation category k are represented by OCC(k) and computed from L as follows:

$$\mathbf{OCC} = \mathbf{L} * \mathbf{X} \tag{21}$$

The occupation by industry matrix L is available for the year 1984 from the Bureau of Labor Statistics.[22] It provides data on approximately 679 occupations and 331 industries. Self employed persons are not included in the basic data. Data is available, however, on the total number of self employed persons by occupation.[23] When it is necessary to include self-employed persons, elements of the matrix L are increased under the assumption that the percentage of people in an occupation that are self employed does not depend on the industry in which they work. That is, if 10 percent of all machine operators are self employed, 10 percent of all machine workers in the metal container industry are self employed. If the total number of self employed persons in an occupation SEL(k) are known, a labor matrix including self employment can be constructed as follows:

$$L'(k,i) = L(k,i) * [1 + SEL(k) / \sum_{i=1}^{i=85} L(k,i)]$$

Collapsing the 331 BLS industries to BEA's 85 allows the construction of a crude measure of labor productivity by simply dividing total industry output by total industry employment.[24]

$$PROD(i) = X(i) / \sum_{k=1}^{k=679} L'(k,i)$$

A matrix L″ that keeps staffing patterns the same with in industry but increases productivity (equivalent to an assumption that the productivity of all occupations in the industry increase by the same percentage) can be computed as follows:

$$L''(k,i) = L'(k,i) * [OLD\ PROD\ (i)]/[NEW\ PROD\ (i)]$$

Converting to 10 Industries and 16 Occupations

Since 79 categories of commodities and industries could not be conveniently displayed in the text, the results of the 79-industry calculations were summarized using ten business sectors. Their relationship to the standard input-output industry categories is shown in table A-2.

Since 679 occupation categories are clearly also unmanagable, the occupation data was compressed to show 45 occupation categories for most calculations. These 45 occupation categories can in turn be reduced to 16 or 11 categories. The 16 category aggregation is used whenever possible since it provides somewhat better detail on occupations of interest to this study. The 11 category set is used when it is necessary to be consistent with some historical BLS series. Table A-3 provides a map showing how the three categories are related.

Constructing Demand Scenarios

The analysis described in the text is built from a series of models. Scenarios are created in the following steps:

1. Estimating U.S. population by age and sex.
2. Estimating numbers of households by type and by income.
3. Estimating spending patterns by households of different types and incomes.
4. Estimating the demand for the output of the business categories for which input-output data is available.
5. Estimating the output of different businesses that result from domestic demand.
6. Estimating how trade affects the output of businesses by business category.
7. Estimating the employment created in different business categories given estimates of yearly output and industry productivity.
8. Estimating jobs by occupations.

Each of these steps provides techniques for understanding trends during the past few decades, which can be used as the basis for constructing estimates about the future that were described in the input-output section appear-

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[21] See Andrew G. Clem and William D. Thomas, "New Weight Structure being Used in Producer Price Index," *Monthly Labor Review*, August 1987; and Elizabeth Gibbons and Gerald F. Halpin, "Import Price Delines in 1986 Reflected Reduced Oil Prices," *Monthly Labor Review*, April 1987.

[22] "1984 Industry by Occupation Matrix," Bureau of Labor Statistics, Office of Economic Growth and Employment Projections, unpublished, June 1985.

[23] "Total Employment by Occupation, 1984 and 1995 Projected," Bureau of Labor Statistics, Office of Economic Growth and Employment Projections, unpublished, June 1985.

[24] Use of U.S. Department of Labor, Bureau of Labor Statistisc, "BLS Input-Output Industry Sectors," unpublished; and U.S. Department of Commerce, Bureau of Economic Analysis, "Appendix B: Industry Classification of the 1977 Input-Output Tables," *Survey of Current Business*, vol. 64, No. 5, May 1984, p. 80.

Table A-2.—Grouping the 79 Input-Output Industries Into 10 Summary Sectors

Natural Resource Intensive Production
1. Livestock and livestock products
2. Other agricultural products
3. Forestry and fishery products
4. Agricultural, forestry, and fishery services
5. Iron and ferroalloy ores mining
6. Nonferrous metal ores mining, except copper
7. Coal mining
8. Crude petroleum and natural gas
9. Stone and clay mining and quarrying
10. Chemical and fertilizer mineral mining

Construction
11. New Construction
12. Maintenance and repair construction

Low Wage Manufacturing[a]
16. Broad and narrow fabrics, yarn, and thread mills
17. Miscellaneous textile goods and floor coverings
18. Apparel
19. Miscellaneous fabricated textile products
20. Lumber and wood products, except containers
21. Wood containers
22. Household furniture
23. Other furniture and fixtures
32. Rubber and miscellaneous plastic products
33. Leather tanning and finishing
34. Footwear and other leather products
64. Miscellaneous manufacturing

Medium Wage Manufacturing
14. Food and kindred Products
26. Printing and publishing
36. Stone and clay products
40. Heating, plumbing, and structural metal products
41. Screw machine products and stampings
42. Other fabricated metal products
44. Farm and garden machinery
47. Metal working machinery and equipment
49. General industrial machinery and equipment
50. Miscellaneous machinery, except electrical
51. Office, computing, and accounting machines
52. Service industry machines
53. Electrical industrial equipment and apparatus
54. Household appliances
55. Electric lighting and wiring equipment
56. Radio, TV, and communication equipment
57. Electronic components and accessories
58. Miscellaneous electrical machinery and supplies
62. Scientific and controlling instruments
63. Optical, ophthalmic, and photographic equipment

High Wage Manufacturing
13. Ordinance and accessories
15. Tobacco manufacturers
24. Paper and allied products, except containers
25. Paperboard containers and boxes
27. Chemicals and selected chemical products
28. Plastic materials and synthetic materials
29. Drugs, cleaning, and toilet preparations
30. Paints and allied products
31. Petroleum refining and related industries
35. Glass and glass products
37. Primary iron and steel manufacturing
38. Primary nonferrous metals manufacturing
39. Metal containers
43. Engines and turbines
45. Construction and mining machinery
46. Materials handling machinery and equipment
48. Special industry machinery and equipment
59. Motor vehicles and equipment
60. Aircraft and parts
61. Other transportation equipment

Transportation and Trade
65. Transportation and warehousing
68. Electric, gas, water, and sanitary services
69. Wholesale and retail trade
74. Eating and drinking places

Transactional Activities
66. Communications, except radio and television
67. Radio and TV broadcasting
70. Finance and insurance
71. Real estate and rental
73. Business services

Personal Services
72. Hotels: personal and repair services (exc. auto)
75. Automobile repair and services
76. Amusements
84. Household Industry

Social Services
77. Health, education, & social services
78. Federal government enterprises
79. State and local government enterprises
82. Government industry n.e.c., excluding defense

Defense
82. Government industry, defense only

[a] 1984 Wages and Salaries per Full-Time Equivalent Employee by Industry (NIPA Table 6.4B and 6.7B) were ranked and divided into 3 groups of 7 industries each. These industries were matched to BEA Input-Output Categories via an unpublished mapping system provided by the BEA.

ing earlier in this appendix. The section that follows will provide details on the first three steps.

A closed model would ensure consistency in the way that the production recipes affect prices that in turn influence consumption. Income available to different occupations would be used to compute income distribtuion, which would also influence consumption.[25] The scenarios examined in this work are forced into consistency in that both demand and value-added are forced to conform to the same total GNP in the year 2005. A closed model capable of exploring structural changes of the magnitude examined in this analysis, and capable of maintaining consistency over 20-year periods, would require precise data in many areas where existing data are not available. Indeed many of the most critical pieces of information (e.g. the cross elasticities between information and transportation demand) are unknowable. The assumptions needed to make such a model work in the absence of

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[25] See Duchin and Leontief, op. cit., footnote 13.

Table A-3.—Grouping 45 Occupation Classifications in a 16-Occupation Set and an 11-Occupation Set

Executive, Administrative, and Managerial
- *Managers and Management Support*
  - Managerial and administrative occupations
  - Management support occupations

Professional Specialty
- *Technical Professionals*
  - Engineers
  - Architects and surveyors
  - Natural, computer, and mathematical scientists
- *Education and Health Professionals*
  - Teachers, librarians, and counselors
  - Health diagnosing and treating occupations
- *Other Professionals*
  - Social scientists
  - Social, recreational, and religious workers
  - Lawyers and judges
  - Writers, artists, entertainers, and athletes
  - All other professional, paraprofessional, and technicians workers

Technicians and Related Support
- *Technicians*
  - Health technicians and technologists
  - Engineering and science technicians and technologists
  - Technicians, except health and engineering and science

Sales
- *Sales Workers*
  - Marketing and sales occupations

Administrative Support, including clerical
- *Other Customer Contact*
  - Adjusters and investigators
  - Information clerks
- *Information Distribution*
  - Communications equipment operators
  - Mail and message distribution workers
  - Duplicating, mail, and other office machine operators
  - Material records, scheduling, dispatching, and distribution
- *Data Entry, Manipulation, and Processing*
  - Computer operators and peripheral equipment operators
  - Financial records processing occupations
  - Records processing occupations, except financial
  - Secretaries, stenographers, and typists
  - Other clerical and administrative support workers

Private Household and Other Service
- *Food and Beverage Preparers*
  - Food and beverage preparers and service occupations
- *Other Service Workers*
  - Cleaning and building service occupations, except private household
  - Health service and related occupations
  - Personal service occupations
  - Private household workers
  - Protective service occupations
  - All other service occupations

Precision Production, Craft, and Repair
- *Precision Production, Craft, and Repair*
  - Blue collar worker supervisors
  - Construction trades
  - Extractive and related workers, including blasters
  - Mechanics, installers, and repairers
  - Precision production occupations
  - Plant and system occupations

Machine Operators, Assemblers, and Inspectors
- *Machine Operators, Assemblers, and Inspectors*
  - Machine setters, set-up operators, operators, and tenders
  - Hand working occupations, including assemblers and fabricators

Transportation and Material Moving
- *Transportation and Material Moving*
  - Transportation and material moving machine and vehicle operators

Handlers, Equipment Cleaners, Helpers, and Laborers
- *Handlers, Equipment Cleaners, Helpers, and Laborers*
  - Helpers, laborers, and material movers

Farming, Forestry, and Fishing
- *Farming, Forestry, and Fishing*
  - Agriculture, forestry, fishing, and related occupations

KEY: The 11-occupation aggregation shown in bold are commonly used in Bureau of Labor Statistics time series.
The 16-occupation aggregation shown in italics are used in most of the summary statistics presented in this document.
The 45-occupation groups 1-45 are subheadings of the 679-occupation categories available from the Bureau of Labor Statistics data.

credible statistics are large, and often difficult to interpret. The methods described below are designed to make the best possible use of existing data, while allowing speculative assumptions to be kept clearly in view.

Demographics

Estimates of the future U.S. population by age and sex were made using a demographic model developed by the U.S. Social Security Administration (SSA)[26] and adapted for use on a personal computer.[27] The assumptions used in the calculations follow those used by SSA—with the exceptions noted:

- *Three mortality rate alternatives.* These translate into an assumed increase in U.S. life expectancy (from birth) of between 2 and 7 years over the next 20 years.
- *Three fertility rate alternatives.* The lowest is 1.6 births per woman and the highest 2.3, with a midpoint of 2.0. Fertility rates fell sharply from 3.4 in

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[26] U.S. Department of Health and Human Services, Social Security Administration, "Social Security Area Population Projections, 1984," Actuarial Study No. 92, Washington, DC, May 1984.

[27] U.S. Congress, Office of Technology Assessment, "Modified Social Security Population Projection Program," working paper prepared for the Economic Transition Project, November 1985.

the baby boom period of the early 1960s to well below 1.8 during the mid 1970s, but have since risen slightly and are now above 1.8.

There has been some debate about whether, over the long term, the U.S. fertility rate will remain below the "replacement rate"—which allows the long term natural rate of increase of the U.S. population to remain positive—of 2.1. A long term rate of 1.9 or less will mean that, even accounting for immigration, the rate of natural increase will become negative toward the end of the 21st century.[28]

- *Immigration projections.* Although net legal immigration has stood at an annual average rate of just over 500,000 persons during the past decade, the effects of immigration reform may cause this figure to increase. In so far as amnesty provisions now apply to all illegal aliens who arrived in the United States prior to 1982, the number of legal immigrants may rise significantly, while the illegal immigrant population declines.

Illegal immigration, however, is more difficult to predict. Over the next 20 years, this factor will depend heavily on economic conditions in developing countries (particularly in Central and South America). Indeed, immigration pressures resulting from economic failure in developing nations could have as great an impact on the U.S. economy as the disruption in trade that such failures cause. In this study, it is assumed that illegal immigration will, after an initial decline through the early 1990s, creep back to currently estimated levels. This would place annual net legal and illegal immigration in 2005 at close to 1 million.[29]

By way of comparison, the U.S. Census Bureau's "high" series for net immigration, which also assumes a significant level of illegal immigration, matches the current overall level cited here of roughly 750,000 (though OTA estimates an increase by 2005). The Census "middle" series assumes only a small rate of illegal immigration.[30] The comparatively high rates of illegal immigration assumed here result in population estimates for the year 2005 that are slightly higher than those projected by SSA; roughly, the middle estimate used here is roughly similar to the SSA high estimate.

These assumptions can be converted to population estimates for the year 2005 using standard demographic techniques. Results of the projections show an annual average increase in total population of between 0.76 and 1.06 percent, with a median estimate—the one most frequently used in the projections that follow—of 0.93 percent. This annual growth rate would place the U.S. population at 292 million by 2005—some 23 percent higher than the 1983 population of 238 million. By way of comparison, the annual average increase in population between 1960 and 1983 was 1.1 percent, while the U.S. Census Bureau's estimates for 2005 show an overall population increase from 1983 of 25.9 percent for the "high" series and 17.7 percent for the "middle" series (annual rates of increase of 1.05 and 0.74, respectively). The incorporation of illegal immigration into the estimates used in this analysis accounts for the difference between the OTA median estimate and the Census "middle" series.[31]

Households

Estimates of population by age and sex can be used to estimate the number of households of different types. The estimates assumed that people of any age and sex are as likely to be in any of 17 household types in 2005 as they were in 1984. This implicitly assumes that divorce and marriage rates remain unchanged. The 17 household types are listed in table A-4. The probabilities were computed for each age and sex using the 1984 Current Population Series (CPS).[32]

All U.S. households were ranked by income per family member using CPS data. This ranked list was divided into seven equal groups—each group representing different income-per-family-member cohorts. It was then possible to compute the percent of all households of a given type that were in each of the seven income cohorts. Unless otherwise noted, it was assumed that the income distribution of each household type remained unchanged. Household income for each household type and income cohort could therefore be estimated given information about total personal income available.

Spending by Household Groups

The initial projection of patterns of consumer expenditures to 2005—the Trend scenarios—rests on the assumption that these expenditures will be based on existing relationships between expenditure by household type and income, and historically based price trends. The existing relationship between expenditures, household types and household income is defined by the patterns of expendi-

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[28] For some interesting perspectives on the issue, see Ben J. Wattenberg, *The Birth Dearth* (New York, NY: Pharos Books, 1987), chapter 3.

[29] F.D. Bean et al., "Projections of Net Legal and Illegal Immigration to the United States," contract paper prepared for the Office of Technology Assessment by the Population Research Center, University of Texas, Austin Texas, August 1984.

[30] U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 952, *Projections of the Population by Age, Sex, and Race: 1983 to 2080* (Washington, DC: U.S. Government Printing Office, 1984).

[31] For a review of the Census Projections, see U.S. Bureau of the Census, *Projections of the Population by Age, Sex, and Race: 1983 to 2080*, op. cit.

[32] U.S. Department of Commerce, Bureau of the Census, digital files. See "Household Formation Program," working paper prepared for the Office of Technology Assessment, Washington, DC, May 1986.

Table A-4.—The 17 Household Types Used To Construct Demand Scenarios

1. Single consumer unit, age 15 to 34
2. Single consumer unit, age 35 to 64
3. Single consumer unit, age 65 and Over
4. Two or more unrelated adults living together, age 15 to 64 (no children) (excluding household type #13)
5. Married couples living without any children, age 15 to 65
6. Single parent with children under 18, age 15 to 65 (excluding household type #14)
7. Married couples with own child, oldest child under 6, householder age 15 to 65 (excluding household type #15)
8. Married couples with own child, oldest child 6 to 17, householder age 15 to 65 (excluding household types #16 & #17)
9. Family or couple headed by a person at least age 65
10. Married couples with own child, oldest child over 17, householder age 15 to 65 (excluding household type #12)
11. All other units
12. Married couples with own child, oldest child over 17, householder under 65, with *only* one child
13. Two unrelated adults living together, age 15 to 64 (no children)
14. Single parent with children under 18, age 15 to 65, with *only* one child under 18
15. Married couples with *only* one child under 6, householder age 15 to 65
16. Married couples with *only* one child age 6 to 17, householder age 15 to 65
17. Married couples with *only* two children, oldest child's age is between 6 and 17, householder age 15 to 65

ture of the U.S. Bureau of Labor Statistics' "Consumer Expenditure Survey" (CES) for 1982/83. The underlying logic of the model is that as household incomes and types of households change, the spending patterns of households change to resemble the established expenditure patterns of income cohort and type into which they have moved.[33] Alternative consumption scenarios were constructed from the base established in the Trend scenarios following methods outlined in chapter 3.

The effect of demographics and household income on consumption patterns was estimated using statistics available from the CES. Regression coefficients were computed using an equation linking expenditure in each household type to household income for each of 31 commodites. The categories were chosen to be as closely compatible as possible with the categories used in the National Income and Product Accounts Personal Consumption Expenditure (PCE) accounts (see table A-5). Expenditures on these 31 items accounted for 75 percent of total PCE in 1983.

Expenditures on the remaining 9 items—health, education, gasoline, electricity, natural gas, other household fuels, stationery, religion and welfare, and foreign travel—are estimated independently (see ch. 3).

This was necessary because expenditure data in the CES, on which the model is based, is incomplete or because there was reason to believe that a price and income coefficients provide an unsatisfactory guide to the future even in the trend cases. For example, the CES covers only out of pocket medical expenses, which account typically for about one quarter of total medical care expenditures. Education from the CES presents another problem since demographic changes, in particular the slow growth of the school age population, will have a greater impact on household educational expenditure than household income or type of household. For energy items, the impact of improved efficiencies is not reflected in existing patterns of household expenditure. The remaining three items—stationery, religion and welfare, and foreign travel—were not separately identified in the CES data.

The influence of income on consumption in 31 categories was computed separately for 17 household types (see table A-4). The equation used was as follows:

$$EX(h,j,I) = a(h,j) + b(h,j)*I + c(h,j)*I^2 \qquad (22)$$

Where EX(h,j,I) is the annual expenditure of household type h for commodity type j when the household income is I. The coefficients a(h,j), b(h,j), and c(h,j) were computed by the Bureau of Labor Statistics. A quadratic form was used so that saturation effects and declines in purchases of "inferior goods" with income could be detected.

Expenditures are multiplied by a price adjustment factor based on an assumed future price changes and a set of price elasticities taken from an examination of the Consumer Expenditure Series data (see table A-6).[34] If the adjustment factor is over 1, for example, total expenditure on a given item will be higher than it otherwise would be if prices had not been taken into account. Some adjustments were made to ensure that the set of price changes and elasticities formed a consistent set. A consistent set leave total spending by a household unchanged (e.g. total spending before the price change is equal to total spending after the price change with spending on each commodity adjusted using the elasticities for each commodity).

In the course of developing the model a number of price adjustments were used. A first series (series A of table A-6) was based on an assumed continuation of 1963-83 trends in relative prices.[35] However, series A resulted in a set of 2005 expenditures that were questionable because they sometimes resulted in projections that often departed significantly from historical trends. A major departure from a trends does not necessarily mean that the result is unrealistic. It does require a search for a plausible ex-

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[33] "Consumer Demand Projection Program," working paper prepared by L. Renner for the Office of Technology Assessment, April 1986.

[34] Paul Devine, "Forecasting Personal Consumption Expenditures from Cross-section and Time-series Data," Ph.D dissertation, University of Maryland, 1983.

[35] U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts, historical diskettes, table 7.10.

Table A-5.—Consumption Items Estimated Using Income and Price Equations and Items Estimated Using Other Methods (1983 spending in each category in billions)

Independently estimated[a]		Estimated using price and income[b]	
Stationery	5.8	Food at home	265.0
Religion and welfare	47.6	Food away from home	104.7
Foreign travel	18.9	Alcohol	52.3
Education	35.1	Tobacco	28.0
Health	267.8	Owner-occupied housing	233.9
Gasoline	90.1	Tenant-occupied housing	96.8
Natural gas	28.9	Maintenance services	8.1
Electricity	51.3	Maintenance commodities	23.6
Household fuels	17.5	Tenants insurance	16.4
Total	533.0	House furnishings	60.2
		House appliances	30.9
% of PCE	**24.8**	Water and sewer	13.3
		New vehicles	87.0
		Used vehicles	21.6
		Vehicle maintenance	70.7
		Other private transport	1.2
		Air fare	14.3
		Other public transport	9.4
		Personal care commodities	20.4
		Personal care services	14.0
		Men's and boys' clothing	38.6
		Women's and girls' clothing	76.4
		Other apparel	24.5
		Footwear	20.3
		Apparel services	7.6
		Telephone	37.9
		Personal business	132.5
		Entertainment services	58.2
		Entertainment commodities	62.4
		TV and sound	31.4

[a] See ch. 3 for a discussion of the techniques used for the independent estimates.

[b] Calculated using the quadratic equations linking expenditures for 17 household types to household income and using price elasticities described in table A-5. The 31 categories in this list totaled 75.2% of all consumer expenditure in 1984.

planation and a judgment about which "trend" to use as the basis for constructing scenarios.

A second price series (series B in table A-6) was developed as a result of a detailed review of consumption trends. In most cases, series B retains the same price elasticities but changes assumptions about future prices. The adjustments are discussed in chapter 3. The most notable case is items of clothing. In the past, prices of clothing fell sharply by about 34 percent between 1963 and 1983. An assumed continuation of this trend in future as in price series A results in a large increase in the share of total expenditure devoted to clothing, representing a major departure from historical trends. The question then becomes whether to use the "trends" established by price elasticities or trends emerging from other variables. Expenditures on Clothing and Personal Care, have represented about 9 percent of PCE over the last 20 years. The results of the expenditure model including series A price adjustment would have increased expenditures on clothing to over 12 percent of total PCE. In order to arrive at a Trend scenario more in keeping with the historical development of expenditures, it was therefore assumed that prices would remain constant in real terms.

Consumption Scenarios

In the Trend scenarios, personal consumption expenditures are projected for two different scenarios for annual economic growth rates: 1.5 percent and 3 percent. Since it is assumed that PCE will retain a constant share of GNP, the total level of expenditure on personal consumption in 2005 is therefore established in advance. The purpose of the Trend projection for PCE then is to estimate the *distribution* of expenditure on different items within that pre-determined total.

Equation (22) can be used to estimate spending in each household type given information about household incomes. The projections of expenditure derived from the model are combined with the independently estimated items to provide projected expenditures on all items of PCE for 2005 under the 1.5 percent and 3 percent growth assumptions. These expenditures are shown in table A-

Table A-6.—Price Assumptions

	Series A			Series B		
	Price elasticity	Price ratio	Price adjustment factor	Price elasticity	Price ratio	Price adjustment factor
Food at home	−0.390	1.012	0.9953	−0.39	1.012	0.995
Food away from home	−0.530	1.224	0.8984	−0.98	1.224	0.82
Alcoholic beverages	−0.160	0.848	1.0267	0.2	0.59	0.9
Tenant-occupied housing	2.269	1.019	1.0436	2.269	1.019	1.044
Lodging	−0.760	0.643	1.3988	−0.76	0.8	1.185
Tenants insurance & other rental costs	−0.400	1.243	0.9166	−0.4	1.243	0.917
Maintenance & repair services	−0.430	1.412	0.8621	−0.43	1.412	0.862
Maintenance & repair commodities	−1.040	1.188	0.8359	−1.04	1.188	0.836
Telephone	−1.080	0.533	1.9730	−1.12	0.8	1.284
Water & sewer	−0.430	0.633	1.2172	−0.43	0.633	1.217
House furnishings	−1.270	0.803	1.3213	−1	0.803	1.245
Household appliances	−0.830	0.753	1.2654	−0.83	0.753	1.265
Housekeeping services	−0.430	1.412	0.8621	−0.43	1.412	0.862
Men's & boys' apparel	−1.420	0.709	1.6296	−1.42	1	1
Women's & girls' apparel	−1.160	0.580	1.8811	−1.16	1	1
Other apparel	−0.740	0.709	1.2897	−0.74	1	1
Footwear	−0.760	0.643	1.3988	−0.76	1	1
Apparel services	0.410	1.218	1.0842	0.41	1	1
New vehicles	0.130	0.654	0.9462	0.13	0.654	0.946
Used vehicles	−0.410	1.802	0.7854	−0.41	1.802	0.785
Vehicle maintenance & repair	−0.020	0.820	1.0039	−0.02	0.82	1.004
Private transportation services	−0.500	1.510	0.8137	−0.5	1.51	0.814
Air fare	−1.850	0.536	3.1698	−1.85	1	1
Other public transport	−1.140	1.397	0.6830	−1.14	1.399	0.682
Entertainment services	−0.730	0.892	1.0870	−0.73	1.073	0.95
Tobacco products	−0.370	1.179	0.9408	−0.37	1.179	0.941
Personal care commodities	−0.090	0.905	1.0090	−0.09	0.905	1.009
Personal care services	0.570	1.265	1.1433	0.57	1.265	1.143
Entertainment commodities	−1.940	0.652	2.2927	−0.76	0.8	1.185
TV & sound equipment	−1.020	0.293	3.4978	−1	0.7	1.43
Personal business	−0.350	1.302	0.9117	−0.35	1.302	0.912
Owner-occupied housing	2.269	1.019	1.0436	2.269	1.019	1.044

7. Government spending was estimated using techniques already outlined in chapters 2 and 3.

Converting Consumption in the Consumer Expenditure Series (CES) Categories to Consumption in Input-Output (I-O) Categories and Consumption by Amenity Group

Consumption in each of the categories shown must be converted into consumer and government demand in the categories used for the input-output analysis discussed in the first part of this appendix. Two steps were required: first, the consumption by CES categories was converted into the categories used in the National Income and Product Accounts (NIPA) Table 2.4 using data provided by the Bureau of Labor Statistics. Since the CES and the NIPA consumption data come from different sources, there is not an exact correspondence between the two even in cases where there is no ambiguity about definitions.[36] To avoid this problem, the scenarios were computed using 1983 data from NIPA increased by the ratio between the CES estimate for 2005 and the CES base in 1983.

Consumption in NIPA table 2.4 was converted into demand in the input-output categories using the "margins" tables provided with input-output benchmarks (see the discussion in ch. 4).[37] Government consumption was converted to I-O categories using similar tables provided by the U.S. Department of Commerce.

Government spending scenarios were constructed in the categories shown in NIPA tables 3.9, 3.15, and 3.16 of the National Income and Product Accounts. Consumption in the categories of NIPA tables 2.4, 3.9, 3.15, and

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[36] See Raymond Gieseman, "The Consumer Expenditure Survey: Quality Control by Comparitive Analysis," *Monthly Labor Review*, March 1987, pp. 8-14, for a comparison of the CES data series with the National Income and Product Accounts PCE data.

[37] U.S. Department of Commerce, *Survey of Current Business*, op. cit., footnote 2.

3.16 were converted into consumption by amenity type using assumptions detailed in table A-8.

The trend scenarios were used as the basis for constructing the alternative scenarios described in chapter 3. Most of the details are explained in that chapter. Box A-1 provides details on the algorithms used to estimate education costs.

Table A-7.—Personal Consumption Expenditures—1983 and the Scenarios (billions of 1983 dollars)

Amenity	1983 ($)	% Share of total	Trend 3% ($)	% Share of total	Trend 1.5% ($)	% Share of total	ALT 3% ($)	% Share of total	ALT 1.5% ($)	% Share of total
1) FOOD										
Food at home	298.4	13.4	433.0	10.1	402.0	13.0	387	9.1	321	10.4
Food away from home	123.6	5.6	235.0	5.5	146.8	4.7	259	6.1	164	5.3
Tobacco	28.0	1.3	31.2	0.7	35.5	1.1	22	0.5	25	0.8
Total	**450.0**	**20.2**	**699.2**	**16.3**	**584.3**	**18.8**	**668**	**15.7**	**510**	**16.5**
2) HOUSING										
Shelter	330.7	14.8	586.8	13.7	465.2	15.0	565	13.3	429	13.9
Household operation	139.2	6.2	306.9	7.2	221.0	7.1	302	7.1	201	6.5
Utilities	111.0	5.0	163.9	3.8	137.7	4.4	95	2.2	80	2.6
Total	**580.9**	**26.1**	**1,057.6**	**24.7**	**823.9**	**26.6**	**962**	**22.7**	**710**	**23.0**
3) TRANSPORTATION										
Vehicles	108.6	4.9	191.8	4.5	140.2	4.5	192	4.5	162	5.2
Vehicle maintenance	71.9	3.2	134.4	3.1	97.5	3.1	135	3.2	114	3.7
Gasoline and oil	90.1	4.0	81.2	1.9	75.2	2.4	41	1.0	36	1.2
Air fare	15.3	0.7	41.8	1.0	22.3	0.7	52	1.2	27	0.9
Other transport	9.4	0.4	12.7	0.3	10.3	0.3	10	0.2	7	0.2
Total	**295.3**	**13.2**	**461.9**	**10.8**	**345.5**	**11.1**	**430**	**10.1**	**346**	**11.2**
4) HEALTH										
Total	**267.8**	**12.0**	**650.0**	**15.2**	**420.3**	**13.6**	**500**	**11.8**	**418**	**13.5**
5) CLOTHING AND PERSONAL CARE										
Personal care	34.4	1.5	72.2	1.7	51.5	1.7	72	1.7	52	1.7
Clothing	167.4	7.5	378.9	8.8	238.7	7.7	446	10.5	281	9.1
Total	**201.8**	**9.1**	**451.1**	**10.5**	**290.2**	**9.4**	**518**	**12.2**	**333**	**10.8**
6) EDUCATION										
Total	**35.1**	**1.6**	**43.3**	**1.0**	**41.4**	**1.3**	**56**	**1.3**	**48**	**1.6**
7) PERSONAL BUSINESS and COMMUNICATION										
Telephone	37.9	1.7	78.7	1.8	66.2	2.1	111	2.6	92	3.0
Stationery	5.8	0.3	11.1	0.3	8.0	0.3	11	0.3	8	0.3
Personal business	132.5	5.9	282.9	6.6	171.3	5.5	333	7.8	201	6.5
Total	**176.2**	**7.9**	**372.7**	**8.7**	**245.5**	**7.9**	**455**	**10.7**	**301**	**9.7**
8) RECREATION & LEISURE										
Entertainment services	58.2	2.6	154.3	3.6	81.1	2.6	183	4.3	97	3.1
Entertainment commodities	62.4	2.8	149.8	3.5	104.9	3.4	165	3.9	115	3.7
TV and sound	31.4	1.4	87.6	2.0	61.0	2.0	106	2.5	78	2.5
Lodging	13.3	0.6	41.8	1.0	23.3	0.8	84	2.0	51	1.7
Religion and welfare	47.6	2.1	91.2	2.1	65.0	2.1	119	2.8	86	2.8
Foreign travel	8.9	0.4	23.1	0.5	14.4	0.5				
Total	**221.8**	**10.0**	**547.8**	**12.8**	**349.7**	**11.3**	**657**	**15.5**	**427**	**13.8**
Total of above	**2,228.9**	**100.0**	**4,283.8**	**100.0**	**3,100.5**	**100.0**	**4,246**	**100.0**	**3,093**	**100.0**

SOURCE: 1983 data from NIPA. Scenarios from OTA.

Table A-8.—Consumption by Amenity Group Derived From Consumption by the Personal and Government Expenditure Categories of the National Income and Product Accounts (NIPA)

Personal Consumption Expenditures
(line numbers from NIPA Table 2.4)

Food:
3 food purchased for off-premise consumption
4 purchased meals & beverages
5 food furnished employees
6 food produced & consumed on farm
7 tobacco products

Housing:
24 owner-occupied nonfarm dwellings-space rent
25 tenant-occupied nonfarm dwellings-rent
26 rental value farm dwellings
29 furniture
30 kitchen & other appliances
31 china, glassware, tableware, and utensils
32 other durable house furnishings
33 semidurable house furnishings
34 cleaning & polishing preparations
37 electricity
38 gas
39 water & other sanitary services
40 fuel oil & coal
42 domestic services
43 other

Transportation:
65 new autos
66 net purchase of used autos
67 other motor vehicles
68 tires, tubes, etc.
69 repair, greasing, etc.
70 gas & oil
71 bridge, tunnel, ferry, toll roads
72 insurance premiums
74 transit systems
75 taxicabs
76 railway (commuter)
78 railway (except commuter)
79 bus
80 airlines
81 other

Health:
45 drug preparations and sundries
46 ophthalmic products
47 physicians
48 dentists
49 other professional services
50 privately controlled hospitals
51 health insurance

Clothing and Personal Care:
12 shoes & footwear
14 women's & children's clothing
15 men's & boys' clothing
16 standard military clothing
17 cleaning, storage and repair of clothing
18 jewelry & watches
19 other
21 toilet articles & preparations
22 barbershops, beauty salons, and health clubs

Education:
99 higher education
100 elementary & secondary schools
101 other

Personal Communication and Business:
41 telephone & telegraph
35 stationery & writing supplies
56 brokerage charges
57 bank service charges
58 services furnished without payment by financial intermediaries
59 expenses of handling life insurance
60 legal services
61 funeral & burial expenses
62 other

Recreation and Leisure:
27 other
83 books & maps
84 magazines, newspapers, and sheet music
85 nondurable toys and sport supplies
86 wheel goods, sports equipment, boats, and pleasure aircraft
87 radio & TV receivers
88 radio & TV repair
89 flowers, seeds, & potted plants
91 motion picture theaters
92 legitimate theaters
93 spectator sports
94 clubs and fraternal organizations
95 commercial participant amusements
96 parimutuel net receipts
97 other
102 religious & welfare activities
104 foreign travel
105 expenditures abroad by U.S. residents
106 less expenditures in U.S. by foreigners
107 less foreign travel remittance in kind

Government Consumption
(line number and table number from the National Income and Product Accounts March 1986 version)

Food:
32—Table 3.16 agriculture
61—Table 3.15 agriculture

Housing:
26—Table 3.16 sewerage @ **47%**[a]
27—Table 3.16 sanitation @ **47%**
30 & 31—Table 3-16 energy @ **44%**
53 & 54—Table 3-15 housing & urban renewal
55—Table 3.15 water and sewerage @**47%**
57—Table 3.15 energy @ **44%**
25—Table 3.16 water @ **47%**
24—Table 3.16 housing and community development
26—Table 5.4 new residential structures (except mobile homes)
32—Table 5.4 mobile homes
40—Table 5.4 broker's commissions

Transportation:

35—Table 3.16 highways @ **62%**
36 & 37—Table 3.16 water and air transport @ **41%**
38—Table 3.16 transit and railroad @ **50%**
67—Table 3.15 transportation @ **31%**

Health:

15—Table 3.16 health services
16—Table 3.16 hospitals
20—Table 3.16 medical care support
24—Table 3.15 health & hospitals
41—Table 3.15 medical care
50—Table 3.15 hospitals & medical care

Education:

10—Table 3.16 elementary & secondary education
11—Table 3.16 higher education
12—Table 3.16 libraries and other education
13—Table 3.16 other
40—Table 3.16 labor training and services
20—Table 3.15 education
48—Table 3.15 education
78—Table 3.15 labor training and services

Recreation and Leisure:

28—Table 3.16 recreational and cultural activities
56—Table 3.15 recreational and cultural activities

Government, n.e.c.

21—Table 3.16 welfare & social services
44—Table 3.15 welfare & social services
45—Table 3.15 other
26—Table 3.16 sewerage @ **53%**
27—Table 3.16 sanitation @ **53%**
55—Table 3.15 water and sewerage @ **53%**
6—Table 3.16 police
7—Table 3.16 fire
17—Table 3.15 police
18—Table 3.15 fire
19—Table 3.15 correction
8—Table 3.16 correction
35—Table 3.16 highways @ **38%**
36 & 37—Table 3.16 water and air transport @ **59%**
38—Table 3.16 transit and railroad @ **50%**
67—Table 3.15 transportation @ **69%**
41—Table 3.16 commercial activities
30 & 31—Table 3.16 energy @ **56%**
57—Table 3.15 energy @ **56%**
39—Table 3.16 economic development, regulation, and services
33—Table 3.16 natural resources
66—Table 3.15 natural resources
2—Table 3.16 administrative activities
2—Table 3.15 administrative activities
7—Table 3.15 international affairs
74—Table 3.15 economic development
18—Table 3.16 government employees retirement
26—Table 3.15 government employees retirement
19—Table 3.16 worker's compensation insurance
31—Table 3.15 disability
37—Table 3.15 unemployment insurance
73—Table 3.15 postal service

Defense and Space:

22—Table 3.16 veteran's benefits and service
10—Table 3.15 space
51—Table 3.15 other
1—Table 3.9 national defense purchases

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[a] Percentages represent the portion of this expenditure category allocated to the particular amenity with the remaining percentage being attributed to Government, n.e.c. This division was primarily based on the ratio of a commodity's total intermediate use to the sum of its intermediate use plus personal consumer expenditures on the item. This ratio gives a rough indication of personal use as opposed to business or common use of an item; the latter was allocated to the omnibus Government category while the former was assigned to the specific amenity. This division was based on data reported in U.S. Department of Commerce, Bureau of Economic Analysis, "The Detailed Input-Output Structure of the U.S. Economy, 1977," 1984.

Box A-1.—Calculating Education Costs in Different Scenarios

The purpose of this calculation is to compute the time allocations of students and teachers under different assumptions about the use of computer equipment and the cost consequences of the scenarios. For simplicity it is assumed that a program of instruction is divided into three parts: (i) a period during which students are using computers under comparatively loose supervision, (ii) a period during which teachers are lecturing students, (iii) tutorial sessions where a teacher spends time with one or a small number of students. In addition to staff costs for teachers working in each task, education costs include the capital costs of buildings, computer and other equipment, and other overhead costs.

The scenarios are constructed from assumptions on the following topics:

NC = The number of students per teacher in situations where only a room monitor is required.
NM = The number of students per teachers in lectures or similar situations.
NT = The number of students per teachers in tutorials.
R = The overall student teacher ratio in the school system.
FSC = The fraction of time students spend on a computer or other instructional hardware.

A calculation of costs also requires an estimate of overhead personnel required per student, the annualized average cost of computers per student (a function of number of students per screen as well as the cost per screen), and the salaries of each type of teacher.

The variables that must be calculated to estimate time allocations and costs are as follows:

FST = Fraction of student time spent in tutorials
FSM = Fraction of student time spent in lectures
FTC = Fraction of teacher time spent in computer monitoring
FTT = Fraction of teacher time spent in tutorials
FTM = Fraction of teacher time spent in lectures

These unknowns can be computed from the assumptions using the following equations:

a. The fractions showing student time use sum to 1 ($\mathrm{FSC}+\mathrm{FST}+\mathrm{FSM}=1$)
b. The fractions showing teacher time use sum to 1 ($\mathrm{FTC}+\mathrm{FTT}+\mathrm{FTM}=1$)
c. The student teacher ratio in tutorials is NT ($\mathrm{FTT}=\mathrm{R}*\mathrm{FST}/\mathrm{NT}$)
d. The student teacher ratio in tutorials is NC ($\mathrm{FTC}=\mathrm{R}*\mathrm{FSC}/\mathrm{NC}$)
e. The student teacher ratio in tutorials is NM ($\mathrm{FTM}=\mathrm{R}*\mathrm{FSM}/\mathrm{NM}$)

Equations a. and b. can be rewritten as follows:

f. $\mathrm{FSM}=1-\mathrm{FSC}-\mathrm{FST}$
g. $\mathrm{FTT}=1-\mathrm{FTC}-\mathrm{FTM}$

Using equations d. and e. in equation 7 yields

h. $(\mathrm{R}/\mathrm{NT})*\mathrm{FST} = 1-(\mathrm{R}/\mathrm{NC})*\mathrm{FSC}-(\mathrm{R}/\mathrm{NM})*\mathrm{FSM}$

Using equations h. and f., two of the variables can be calculated directly:

$$\begin{aligned}
\mathrm{FSM} &= 1-\mathrm{FSC}-(\mathrm{NT}/\mathrm{R})*1-(\mathrm{R}/\mathrm{NC})*\mathrm{FSC}-(\mathrm{R}/\mathrm{NM})*\mathrm{FSM})\\
\mathrm{FSM}^{*}\quad (1-\mathrm{NT}/\mathrm{NM}) &= 1-(\mathrm{NT}/\mathrm{R})-\mathrm{FSC}*(1-\mathrm{NT}/\mathrm{NC})\\
\mathrm{FSM} &= ((1-\mathrm{NT}/\mathrm{R})+ \mathrm{FSC}*(\mathrm{NT}/\mathrm{NC}-1))/(1-\mathrm{NT}/\mathrm{NN}) \text{ by symetry}\\
\mathrm{FST} &= ((1-\mathrm{NM}/\mathrm{R}) + \mathrm{FSC}*(\mathrm{NM}/\mathrm{NC}-1))/(1-\mathrm{NM}/\mathrm{NT})
\end{aligned}$$

Since FSM and FST have been calculated, equations c.,d., and e. can be used to calculate FTM, FTC, and FTT.

The number of computers required per student can be calculated from FSC and the number of students using a computer at any given time. These variables can be used to calculate the cost of scenarios described in chapter 3.

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